CHAPTER III - SUMMARY OF TROPICAL CYCLONES

1. WESTERN NORTH PACIFIC TROPICAL CYCLONES

During 1983, the western North Pacific experienced the fifth consecutive year of below average tropical cyclone activity. Twenty-five tropical cyclones occurred in 1983, six and one-half less than the annual average. Only two significant tropical cyclones failed to develop beyond the tropical depression (TD) stage and eleven tropical storms (TS) failed to reach typhoon intensity. Of the 12 tropical cyclones that developed to typhoon (TY) intensity, four reached the 130 kt (67 m/s) intensity necessary to be classified as super typhoons (STY). In the western North Pacific, tropical cyclones reaching tropical storm intensity or greater are assigned names in alphabetical order from a list of alternating male/female names (refer to Appendix 3). Table 3-1 provides a summary of key statistics for western North Pacific tropical cyclones. Each tropical cyclone's maximum surface wind (in knots) and minimum observed sea level pressure (in millibars) were obtained from best estimates based on all available data. The distance traveled (in nautical miles) was calculated from the JTWC official best tracks (see Annex A).

Tables 3-2 through 3-5 provide further information on the monthly distribution of tropical cyclones and statistics on Tropical Cyclone Formation Alerts and Warnings.

TABLE 3-1. WESTERN NORTH PACIFIC

1983 SIGNIFICANT TROPICAL CYCLONES

TROPICAL CYCLONE	PERIOD OF WARNING	CALENDAR DAYS OF WARNING	NUMBER OF WARNINGS ISSUED	MAXIMUM SURFACE WINDS (KT)	OBSERVED MSLP (MB)	BEST TRACK DISTANCE TRAVELED (NM)
01W TS SARAH	24 JUN - 26 JUN	3	6	35	999	1948
02C TC 02C	31 AUG - 2 SEP	3	5	30	1010	773
02W TY TIP	10 JUL - 13 JUL	4	14	65	978	1206
03W TY VERA	12 JUL - 18 JUL	7	25	90	952	2546
04W STY WAYNE	22 JUL - 25 JUL	4	14	135	920	1739
05W STY ABBY	5 AUG - 17 AUG	13	51	145	888	2031
06W TS CARMEN	12 AUG - 15 AUG	4	11	45	992	1186
07W TS BEN	12 AUG - 15 AUG	4	12	50	989	968
08W TS DOM	19 AUG - 26 AUG	8	23	55	995	1859
09W TD 09W	26 AUG - 27 AUG	2	4	30	996	522
10W TY ELLEN	29 AUG - 9 SEP	12	47	125	928	4462
11W STY FORREST	20 SEP - 29 SEP	10	32	150	883	2191
12W TS GEORGIA	29 SEP - 1 OCT	3	11	55	987	825
13W TS HERBERT	7 OCT - 8 OCT	2	8	50	987	445
14W TY IDA	7 OCT - 11 OCT	5	15	65	973	1889
15W TY JOE	10 OCT - 13 OCT	4	15	65	975	1654
16W TS KIM	16 OCT - 20 OCT	5	3	40	993	1224
17W TY LEX	22 OCT - 26 OCT	5	18	70	971	718
18W STY MARGE	31 OCT - 7 NOV	8	27	145	896	2370
19W TS NORRIS	9 NOV - 11 NOV	3	7	50	994	721
20W TY ORCHID	17 NOV - 27 NOV	11	38	125	928	2214
21W TY PERCY	19 NOV - 24 NOV	6	23	70	970	1123
22W TS RUTH	23 NOV - 30 NOV	8	16	60	993	1615
23W TS SPERRY	2 DEC - 5 DEC	4	10	55	996	350
24W TS THELMA	16 DEC - 18 DEC	3	10	55	990	1165
	1983 TOTALS:	111*	445			

* OVERLAPPING DAYS INCLUDED ONLY ONCE IN SUM

TABLE 3-2.

WESTERN NORTH PACIFIC

1983 SIGNIFICANT TROPICAL CYCLONES

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	(1959-1982) AVERAGE	CASES
TROPICAL DEPRESSIONS	0	0	0	0	0	0	0	2	0	0	0	0	2	3.9	93
TROPICAL STORMS	0	0	0	0	0	1	0	3	1	2	2	2	11	9.7	232
TYPHOONS	0	0	0	0	0	0	3	2	1	4	2	0	12	17.8	428
ALL TROPICAL CYCLONES	0	0	0	0	0	1	3	7	2	6	4	2	25	31.4	753

1959-1982	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	
AVERAGE	.5	.3	.8	.9	1.4	2.0	5.0	6.2	5.9	4.4	2.6	1.4	31.4	PREVIOUS 24-YEAR HISTORY
CASES	13	8	18	22	33	48	119	149	142	105	63	33	753	

FORMATION ALERTS: 25 of 31 Formation Alerts developed into significant tropical cyclones. Tropical Cyclone Formation Alerts were issued for all significant tropical cyclones that developed during 1983.

WARNINGS:

Number of warning days:	111
Number of warning days with two tropical cyclones in region:	18
Number of warning days with three or more tropical cyclones in region:	6

TABLE 3-3.

FREQUENCY OF TYPHOONS BY MONTH AND YEAR

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
(1945-1958) AVERAGE	.4	.1	.3	.4	.7	1.1	2.0	2.9	3.2	2.4	2.0	.9	16.3
1959	0	0	0	1	0	0	1	5	3	3	2	2	17
1960	0	0	0	1	0	2	2	8	0	4	1	1	19
1961	0	0	1	0	2	1	3	3	5	3	1	1	20
1962	0	0	0	1	2	0	5	7	2	4	3	0	24
1963	0	0	0	1	1	2	3	3	3	4	0	2	19
1964	0	0	0	0	2	2	6	3	5	3	4	1	26
1965	1	0	0	1	2	2	4	3	5	2	1	0	21
1966	0	0	0	1	2	1	3	6	4	2	0	1	20
1967	0	0	1	1	0	1	3	4	4	3	3	0	20
1968	0	0	0	1	1	1	1	4	3	5	4	0	20
1969	1	0	0	1	0	0	2	3	2	3	1	0	13
1970	0	1	0	0	0	1	0	4	2	3	1	0	12
1971	0	0	0	3	1	2	6	3	5	3	1	0	24
1972	1	0	0	0	1	1	4	4	3	4	2	2	22
1973	0	0	0	0	0	0	4	2	2	4	0	0	12
1974	0	0	0	0	1	2	1	2	3	4	2	0	14
1975	1	0	0	0	0	0	1	3	4	3	2	0	15
1976	1	0	0	1	2	2	2	1	4	1	1	0	15
1977	0	0	0	0	0	0	3	0	2	3	2	1	11
1978	0	0	0	1	0	0	3	2	4	3	2	0	15
1979	1	0	1	1	0	0	2	2	3	2	1	1	14
1980	0	0	0	0	2	0	3	2	5	2	1	0	15
1981	0	0	1	0	0	2	2	2	4	1	2	2	16
1982	0	0	2	0	1	1	2	5	3	3	1	1	19
1983	0	0	0	0	0	0	3	2	1	4	2	0	12
(1959-1983) AVERAGE	.2	.04	.2	.6	.8	.9	2.8	3.3	3.2	3.0	1.6	.6	17.4
CASES	6	1	6	15	20	23	69	83	81	76	40	15	435

TABLE 3-4.

FREQUENCY OF TROPICAL STORMS AND TYPHOONS BY MONTH AND YEAR

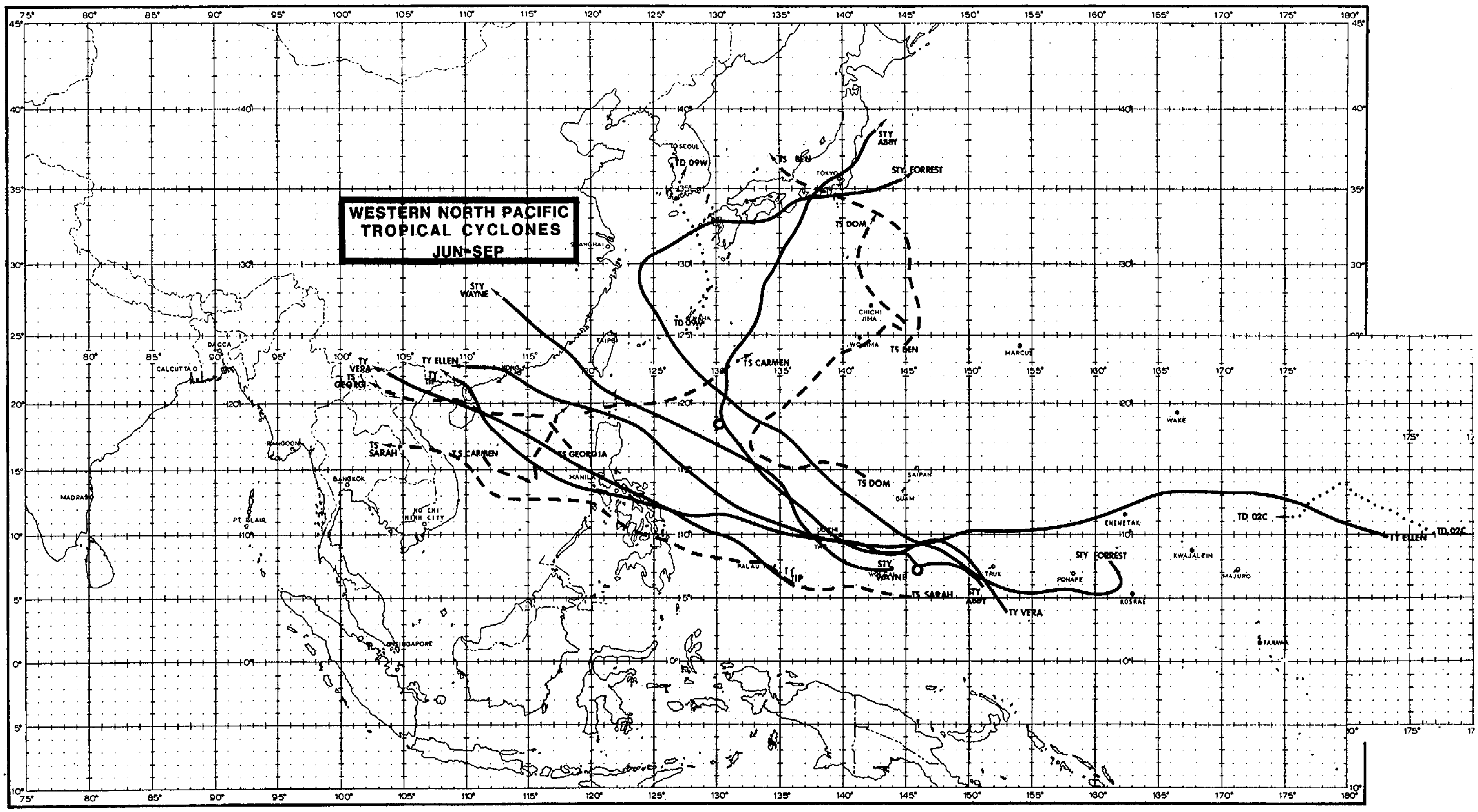
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
(1945-1958) AVERAGE	.4	.1	.4	.5	.8	1.3	3.0	3.9	4.1	3.3	2.7	1.1	21.6
1959	0	1	1	1	0	0	3	6	6	4	2	2	26
1960	0	0	0	1	1	3	3	10	3	4	1	1	27
1961	1	1	1	1	3	2	5	4	6	5	1	1	31
1962	0	1	0	1	2	0	6	7	3	5	3	2	30
1963	0	0	0	1	1	3	4	3	5	5	0	3	25
1964	0	0	0	0	2	2	7	9	7	6	6	1	40
1965	2	2	1	1	2	3	5	6	7	2	2	1	34
1966	0	0	0	1	2	1	5	8	7	3	2	1	30
1967	1	0	2	1	1	1	6	8	7	4	3	1	35
1968	0	0	0	1	1	1	3	8	3	6	4	0	27
1969	1	0	1	1	0	0	3	4	3	3	2	1	19
1970	0	1	0	0	0	2	2	6	4	5	4	0	24
1971	1	0	1	3	4	2	8	4	6	4	2	0	35
1972	1	0	0	0	1	3	6	5	4	5	2	3	30
1973	0	0	0	0	0	0	7	5	2	4	3	0	21
1974	1	0	1	1	1	4	4	5	5	4	4	2	32
1975	1	0	0	0	0	0	2	4	5	5	3	0	20
1976	1	1	0	2	2	2	4	4	5	1	1	2	25
1977	0	0	1	0	0	1	4	1	5	4	2	1	19
1978	1	0	0	1	0	3	4	7	5	4	3	0	28
1979	1	0	1	1	1	0	4	2	7	3	2	2	24
1980	0	0	0	1	4	1	4	2	6	4	1	1	24
1981	0	0	1	2	0	2	5	7	4	2	3	2	28
1982	0	0	3	0	1	3	4	5	5	3	1	1	26
1983	0	0	0	0	0	1	3	5	2	5	5	2	23
(1959-1983) AVERAGE	.5	.3	.6	.8	1.2	1.6	4.4	5.4	4.9	4.0	2.5	1.2	27.3
CASES	12	7	14	21	29	40	111	135	122	100	62	30	683

TABLE 3-5.

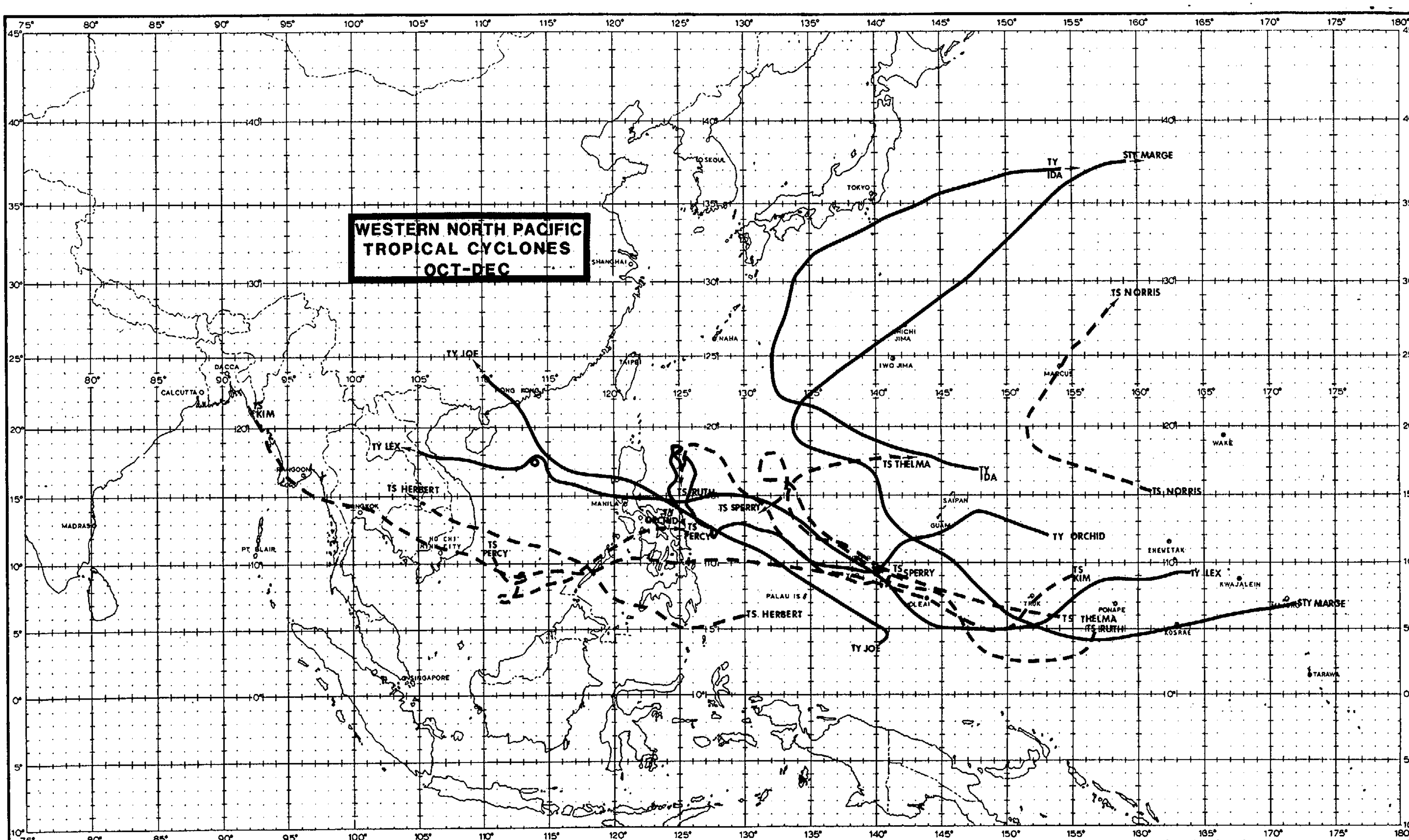
FORMATION ALERT SUMMARY

WESTERN NORTH PACIFIC

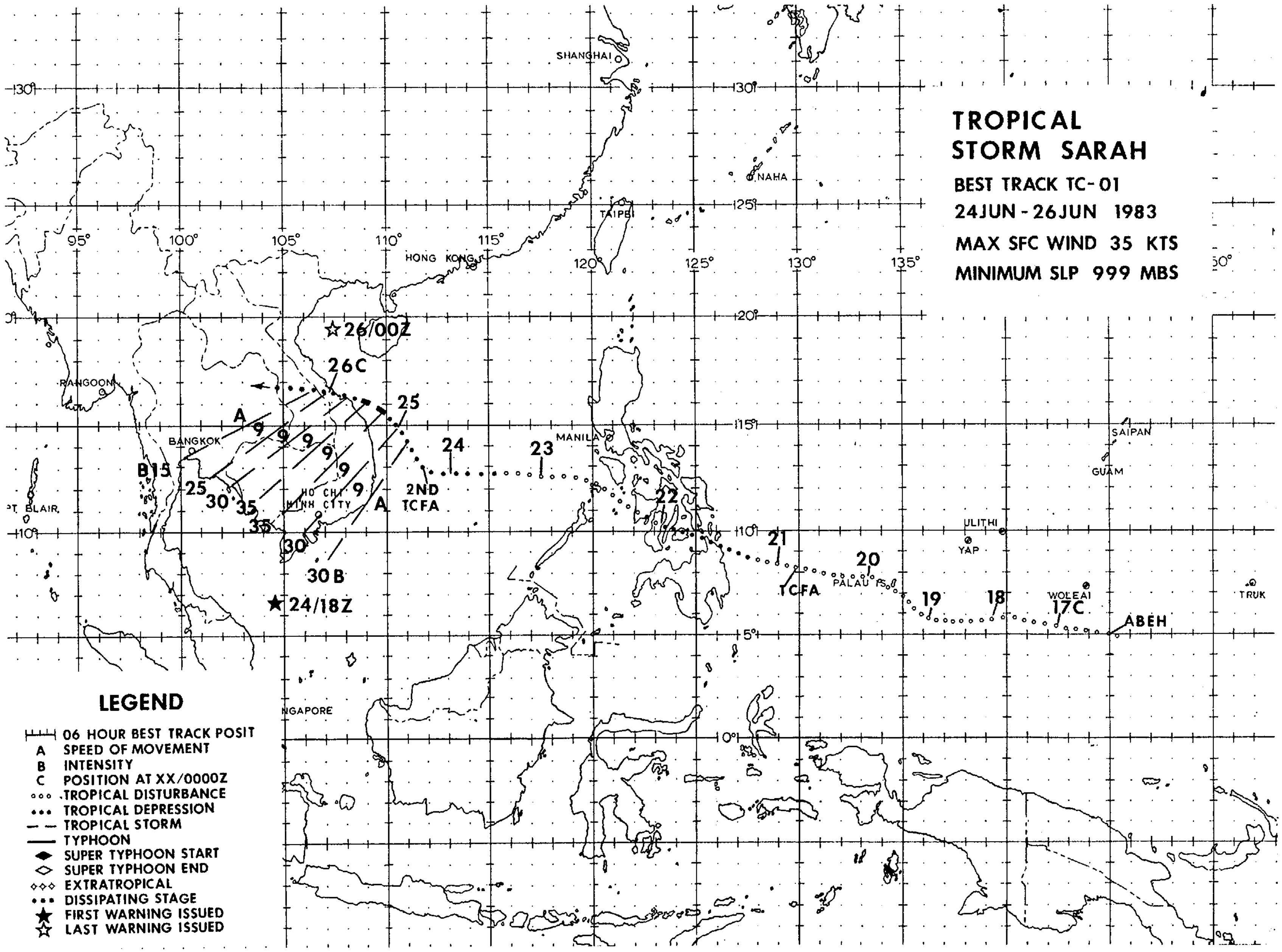
YEAR	NUMBER OF ALERT SYSTEMS	ALERT SYSTEMS WHICH BECAME NUMBERED TROPICAL CYCLONES	TOTAL NUMBERED TROPICAL CYCLONES	DEVELOPMENT RATE
1972	41	29	32	71%
1973	26	22	23	85%
1974	35	30	36	86%
1975	34	25	25	74%
1976	34	25	25	74%
1977	26	20	21	77%
1978	32	27	32	84%
1979	27	23	28	85%
1980	37	28	28	76%
1981	29	28	29	97%
1982	36	26	28	72%
1983	31	25	25	81%
(1972-1983) AVERAGE	32.3	25.7	27.7	80%
CASES	388	308	332	



NOCC GUAM 3142/20 (NEW 5 - 80)



NOCC GUAM 3142/20 (NEW 5 - 80)


TROPICAL
STORM SARAH
BEST TRACK TC-01
24JUN-26JUN 1983
MAX SFC WIND 35 KTS
MINIMUM SLP 999 MBS
LEGEND
06 HOUR BEST TRACK POSIT
A SPEED OF MOVEMENT
B INTENSITY
C POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
DISSIPATING STAGE
FIRST WARNING ISSUED
LAST WARNING ISSUED
SHANGHAI
NAHA
TAIPEI
HONG KONG
RANGOON
BANGKOK
HO CHI MINH CITY
MANILA
SAIPAN
GUAM
ULITHI
YAP
PALAU IS.
WOLEAI
TRUK
PT. BLAIR
NGAPORE
26/00Z
26C
25
24
23
22
21
20
19
18
17C
ABEH
2ND TCFA
TCFA
24/18Z
30B
B15
A
9
25
30
35
95°
100°
105°
110°
115°
120°
125°
130°
135°
30°
25°
20°
15°
10°
5°

The formation of Tropical Storm Sarah in the South China Sea during late June marked the beginning of the 1983 tropical cyclone season for the northwestern Pacific. This was the latest season-opener since 1973 when JTWC issued its first warning of the year in July.

The disturbance that was to eventually spawn Sarah was first detected using satellite imagery on 16 June. It was described on that day in the Significant Tropical Weather Advisory (ABEH PGTW) as a poorly organized area of convection centered near 5N 145E.

An upper-level trough located 600 nm (1111 km) to the northwest contributed to the formation of an area of strong upper-level divergence which appeared to be associated with the convection. As the upper-level trough pushed westward over the next few days, the area of enhanced convection maintained its relative position to the southeast and moved west as well.

It was not until the 19th that a weak surface circulation became apparent from satellite imagery near 6N 136E in the low-level easterly flow. This circulation was located along the southern tip of a narrow band of heavy convection extending northward to near the position of the upper-level trough. As the circulation moved westward, the strongest area of convection remained well to the north. A TCFA was issued at 201930Z when it became apparent from satellite imagery that the convection had become more organized around the circulation and that an upper-level anticyclone had developed over the system. However, the ensuing daylight aircraft investigative mission, at 210025Z found only a weakly defined, 1009 mb surface circulation with winds in excess of 15 kt (8 m/s) observed only in the trade wind flow to the north of the circulation.

Convective activity associated with the circulation persisted and increased sharply as the circulation approached the northern tip of Mindanao. The system was continued in alert status and monitored closely as it crossed the southern Philippines. Synoptic data during this interval indicated the presence of a weak 10-15 kt (5-8 m/s) disturbance which was difficult to track as it crossed the islands. The formation alert was cancelled at 220445Z when satellite imagery indicated that the system had lost its upper-level anticyclone and that its convection had broken up over the mountainous terrain.

Over the next two days the remaining weak surface circulation was observed moving westward into the South China Sea. Convection associated with the circulation was unorganized and strong upper-level northeasterly flow presented a shearing environment that was not considered favorable for further development.

The third, and final, formation alert on this system was issued at 240930Z after convective activity associated with the circulation underwent a marked increase in intensity and organization. Continued intensification, evident from satellite imagery, combined with synoptic reports indicating the presence of 25-30 kt (13-15 m/s) winds, prompted the issuance of the first warning of the 1983 season at 241830Z.

Tropical Storm intensity was reached 12 hours later as Sarah drifted northwestward toward Vietnam. Figure 3-01-1 shows Sarah near maximum intensity off the coast of Vietnam. Further intensification was prevented by intense vertical shear--satellite-derived winds up to 45 kt (23 m/s) over the system--which displaced Sarah's convection to the west.

Under the effects of this hostile shearing environment, Sarah was not able to maintain vertical organization and weakened while approaching the coast of Vietnam. The final warning was issued at 260300Z as Sarah, a fully exposed low-level circulation, moved inland north of Hue and dissipated rapidly.

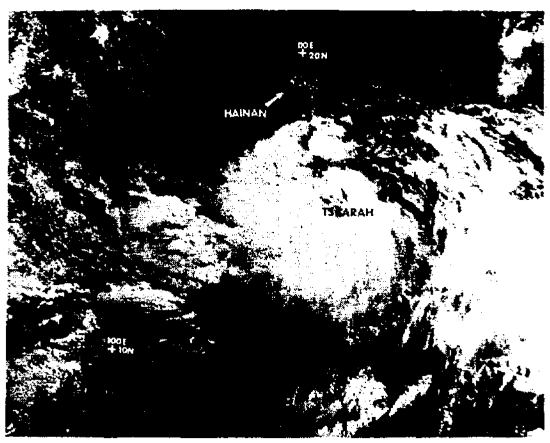
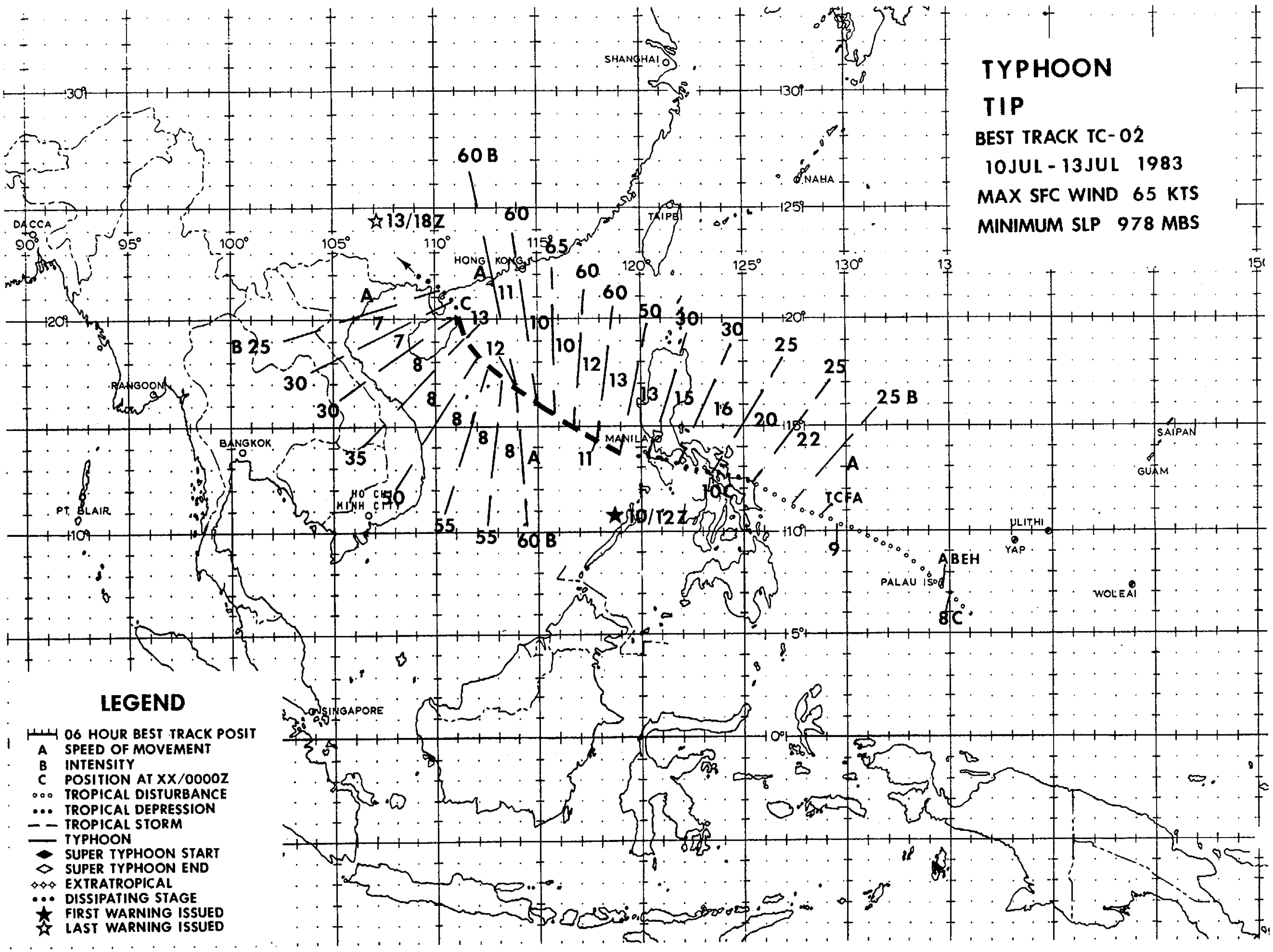


Figure 3-01-1. Tropical Storm Sarah at maximum intensity approaching the coast of Vietnam.



TYPHOON
TIP
BEST TRACK TC-02
10JUL-13JUL 1983
MAX SFC WIND 65 KTS
MINIMUM SLP 978 MBS
LEGEND
06 HOUR BEST TRACK POSIT
A SPEED OF MOVEMENT
B INTENSITY
C POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
DISSIPATING STAGE
FIRST WARNING ISSUED
LAST WARNING ISSUED
SHANGHAI
NAHA
TAIPEI
HONG KONG
MANILA
BANGKOK
RANGOON
DACCA
PT. BLAIR
HO CHI MINH CITY
SINGAPORE
SAIPAN
GUAM
ULITHI
YAP
PALAU IS.
WOLEAI
13/18Z
10/12Z
TCFA

During late June and early July several tropical disturbances were monitored by JTWC. All of these, with the exception of Tropical Storm Sarah (01W), originated in the Philippine Sea and moved westward without developing into significant tropical cyclones. The combination of the rugged Philippine terrain and strong upper-level flow in the South China Sea was sufficient deterrent to development.

On 8 July another disturbance became evident in the Philippine Sea as a persistent area of convective activity near 8N 134 E. Synoptic data indicated that the disturbance was poorly organized with an MSLP of 1008 mb.

On the following day, the disturbance was located near 11N 129E and appeared somewhat more organized on satellite imagery. A weather reconnaissance aircraft on an investigative mission east of Samar was unable to locate a closed circulation, but found a broad area of low presures with maximum surface winds of 25 kt (13 m/s) and MSLP of 1004 mb. In spite of the apparent absence of a well defined surface circulation, a TCFA was issued at 090841Z. The alert was issued because the disturbance was entering an area of strong upper-level divergence associated with a TUTT cell to the northeast. JTWC continued to monitor this disturbance as it moved rapidly across the Philippines, however synoptic data from Philippine land stations indicated that the disturbance remained loosely organized.

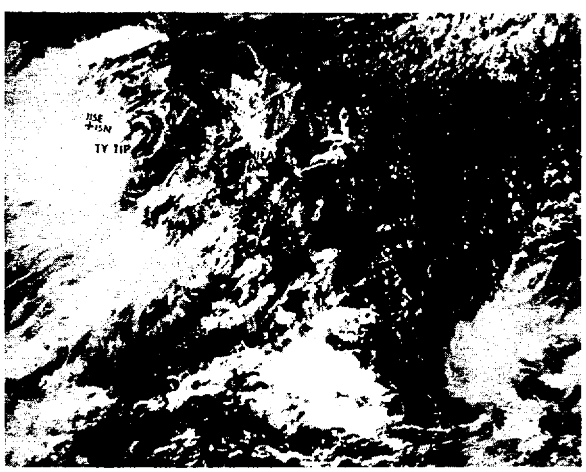


Figure 3-02-1. Typhoon Tip at maximum intensity in the South China Sea. Note the effects of the strong upper-level flow, displacing Tip's convection to the southwest and exposing the low-level circulation (110644Z NOAA 7 visual imagery).

The first warning was issued as the disturbance, now tropical depression 02W, entered the South China Sea north of Mindoro. Synoptic data indicated the presence of a well defined surface circulation with 30 kt (15 m/s) winds and MSLP of 998 mb. From the initial warning, movement to the northwest toward Hainan Island was forecast, with continued intensification and then weakening late in the period. This forecast scenario was based on the expectation that the mid-level easterly steering currents and strong vectical shear in the area whould persist through the forecast period.

Tip lived up to expectations, moving as expected and achieving typhoon intensity at 111200Z. Figure 3-02-1 shows Tip near maximum intensity on the 11th. The effects of the strong upper-level flow are apparent as Tip appears as an exposed low-level circulation with its convection displaced to the southwest. The circulation appearing on the right hand side of the picture is the disturbance which later developed into Typhoon Vera (03W). Figure 3-02-2 is the 200 mb analysis for the area at the time of Tip's maximum intensity. Note the strong northeasterly flow over Tip and the divergent area in which Tip formed to the east.

After attaining maximum intensity of 65 kt (33 m/s) on the 11th, Tip continued to move northwestward and weakened as an exposed low-level circulation. Tip made landfall near Chan Chiang, China on the 13th with maximum sustained winds of 30 kt (15 m/s) and dissipated rapidly over land.

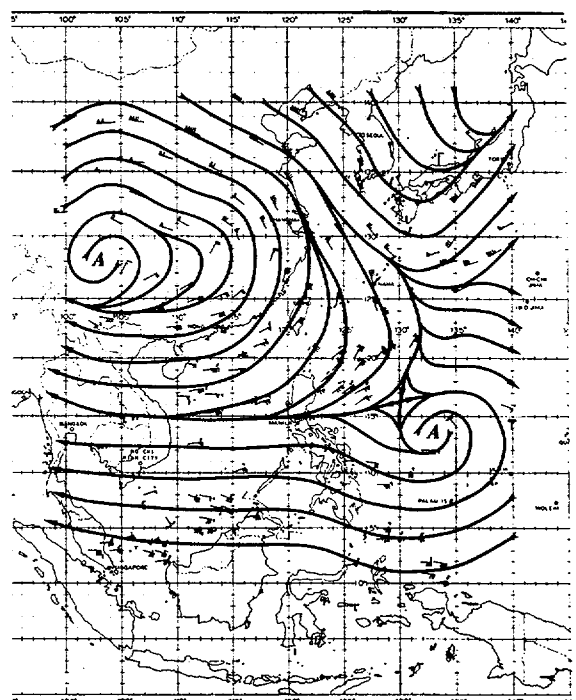
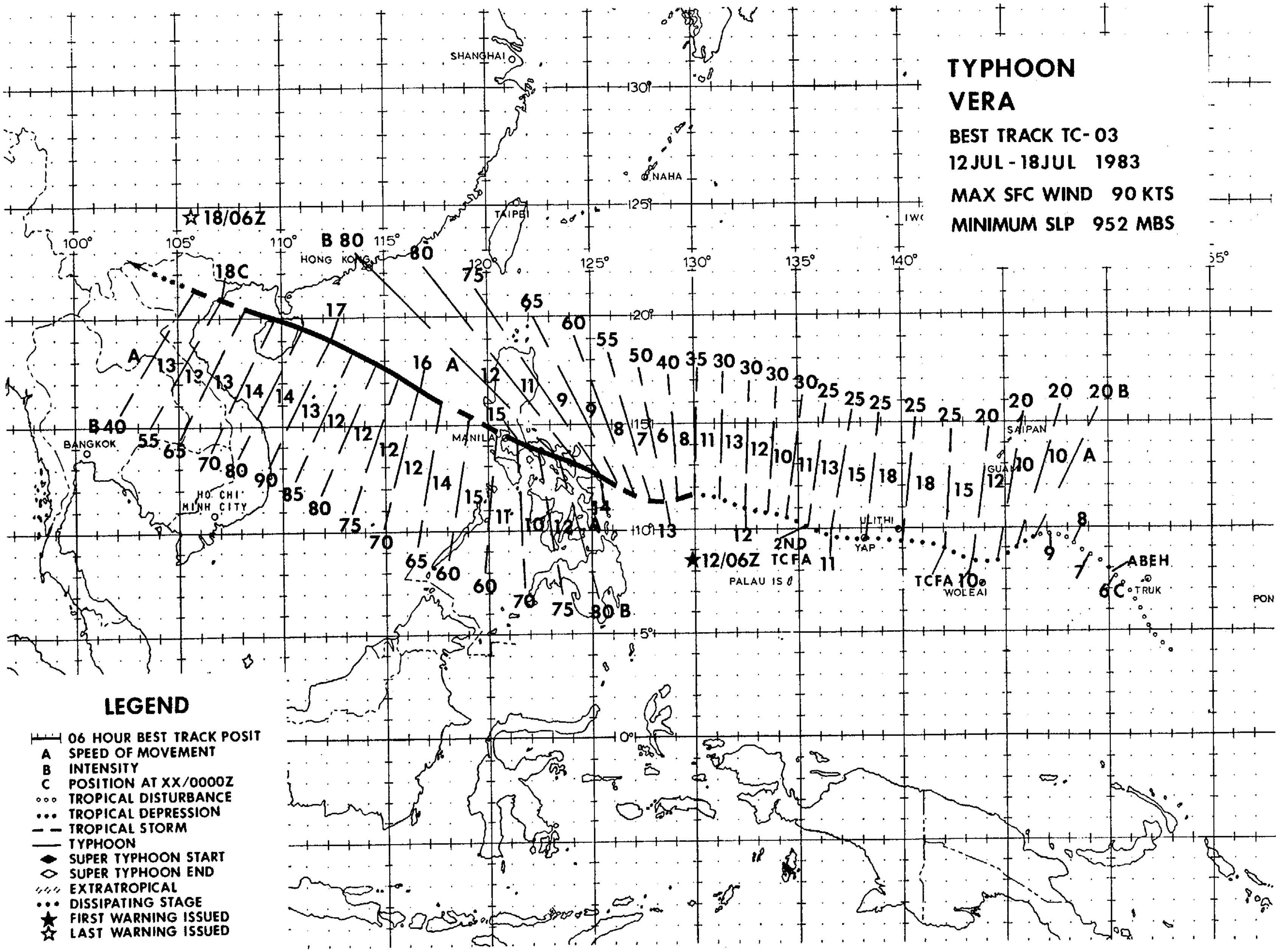


Figure 3-02-2. 111200Z July 200 mb analysis. Note strong northeasterly flow in the South China Sea.


TYPHOON
VERA
BEST TRACK TC-03
12JUL-18JUL 1983
MAX SFC WIND 90 KTS
MINIMUM SLP 952 MBS
LEGEND
06 HOUR BEST TRACK POSIT
A SPEED OF MOVEMENT
B INTENSITY
C POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
DISSIPATING STAGE
FIRST WARNING ISSUED
LAST WARNING ISSUED
SHANGHAI
NAHA
TAIPEI
HONG KONG
BANGKOK
HO CHI MINH CITY
MANILA
SAIPAN
GUAM
ULITHI
YAP
PALAU IS
WOLEAI
TRUK
18/06Z
12/06Z
2ND TCFA
TCFA

In the week that preceded the development of Typhoon Vera, the monsoon trough extended eastward from the Philippines to 160E as a nearly continuous zone of light surface winds and unorganized convection. However, on 4 July, surface westerlies increased to 15 kt (8 m/s) south of the trough and one circulation center, located near Truk Atoll (WMO 91334) became a persistent feature on JTWC gradient-level charts. A noticeable change in convective activity was observed on 8 July, as two distinct cloud masses began to develop within the monsoon trough. This change occurred as two upper-tropospheric cyclones intensified over the Philippine Sea, one east of Luzon about 125E and the other west of Guam about 140E. The upper cyclones increased the upper-level divergence near both convective disturbances and were instrumental in sustaining the development of each during the subsequent three day period. The westernmost disturbance became Typhoon Tip (02W) and the disturbance which moved northwestward from the Truk area became Typhoon Vera.

The first of two TCFAs on Vera was issued at 100600Z, when satellite imagery and 200 mb wind data indicated that a well-defined upper-level circulation had developed over the system. Development of a well-defined surface circulation was slow and the formation alert was reissued at 110600Z after a reconnaissance aircraft investigative mission could not locate a circulation center in the low-level wind field. Figure 3-03-1 shows the suspect disturbance as it appeared on satellite imagery at the time of this reconnaissance mission. Twenty-four hours later, the initial warning was issued for Tropical Depression 03W when data from the next reconnaissance aircraft mission indicated a closed surface circulation with 30 kt (15 m/s) winds and a 1004 mb central sea level pressure.

During the first 36 hours in warning status, Vera intensified quite rapidly and reached typhoon strength by 131800Z. During this period, Vera slowed from an average speed of 12 kt (22 km/hr) to less than 6 kt (11 km/hr). In fact, during one 12-hour period (121200Z to 130000Z), virtually all fix positions were within a 30 nm(56 km) area. On 13 July, Vera turned toward the west-northwest and the central Philippines with the speed of movement increasing to 12 kt (22 km/hr). Vera skirted the northeastern portion of the island of Samar at 140000Z, with maximum sustained surface winds near 75 kt (39 m/s). Figure 3-03-2 shows Typhoon Vera as it entered the Philippines near the island of Samar. Forecasts from this point forward anticipated that Vera would weaken as it tracked through the Philippines. However, satellite imagery continued to indicate an increase in Vera's central cloud features until it reached the rugged terrain east of Manila at 150000Z. Vera then moved into Manila Bay, packing winds near 60 kt (31 m/s), and brought extensive flooding into low-lying areas of the Bay, especially

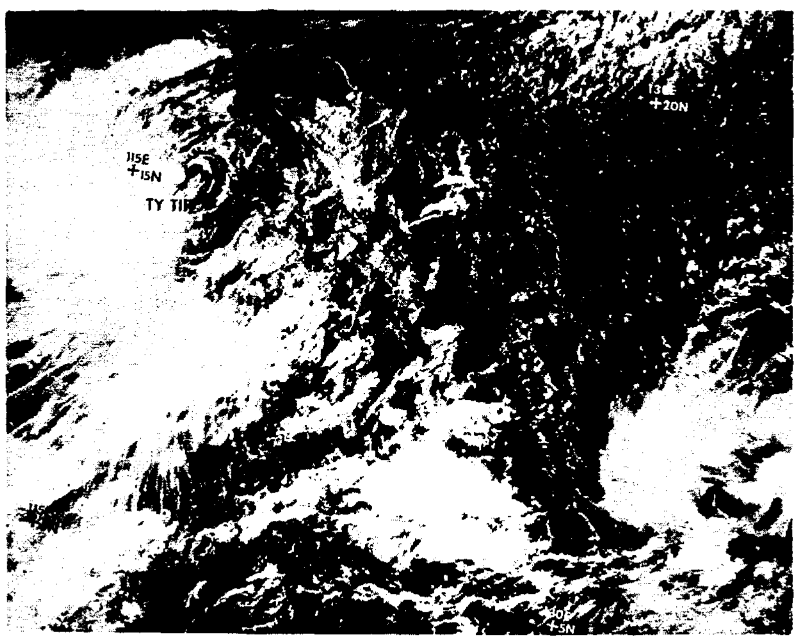


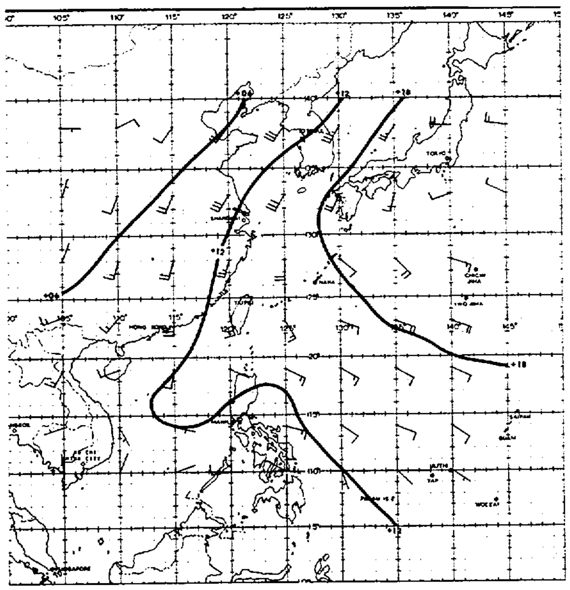
Figure 3-03-1. Typhoon Vera developing 160 nm (296 km) north of Koror at the time that the second formation alert was issued. Typhoon Tip is located to the west in the South China Sea (110644Z NOAA 7 visual imagery).

on Corregidor. Vera passed just southwest of the Naval Air Station, Cubi Point, at 150630Z and into the South China Sea. In its wake, Vera left thousands homeless, nearly 100 people dead and extensive property damage to the southern two-thirds of Luzon.

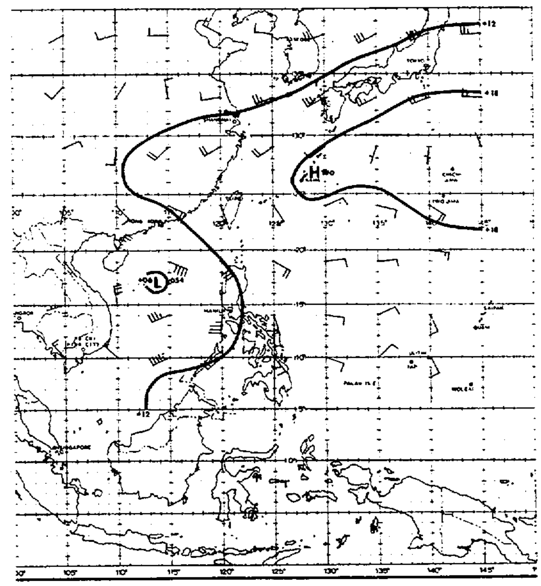
Track forecasts for Vera were quite good except for an anticipated turn northward as the system moved into the South China Sea. Figure 3-03-3 depicts the 48-hour NOGAPS 700 mb prog valid for 161200Z and the verifying analysis. The significant difference between the prognostic chart and the analysis was the extent and orientation of the subtropical ridge over eastern China. The prognostic fields suggested that a track northward was possible; however, as Vera moved west-northwestward into the South China Sea, the ridge built westward and also became narrower between 20N and 30N. As a result, the forecast northward track never materialized and Vera persisted on its west-northwestward track.

On 17 July, as Vera approached Hai-Nan Island, a peak intensity of 90 kt (46 m/s) was attained. Crossing Hai-Nan and moving into the northern portion of the Gulf of Tonkin, Vera slowly weakened before making landfall near Haiphong, Vietnam, at 180000Z. It then weakened rapidly over the mountainous terrain of northern Vietnam.

Figure 3-03-2. Typhoon Vera, located just east of Samar, with maximum winds near 70 kt (36 m/s). (132252Z NOAA 8 visual imagery).

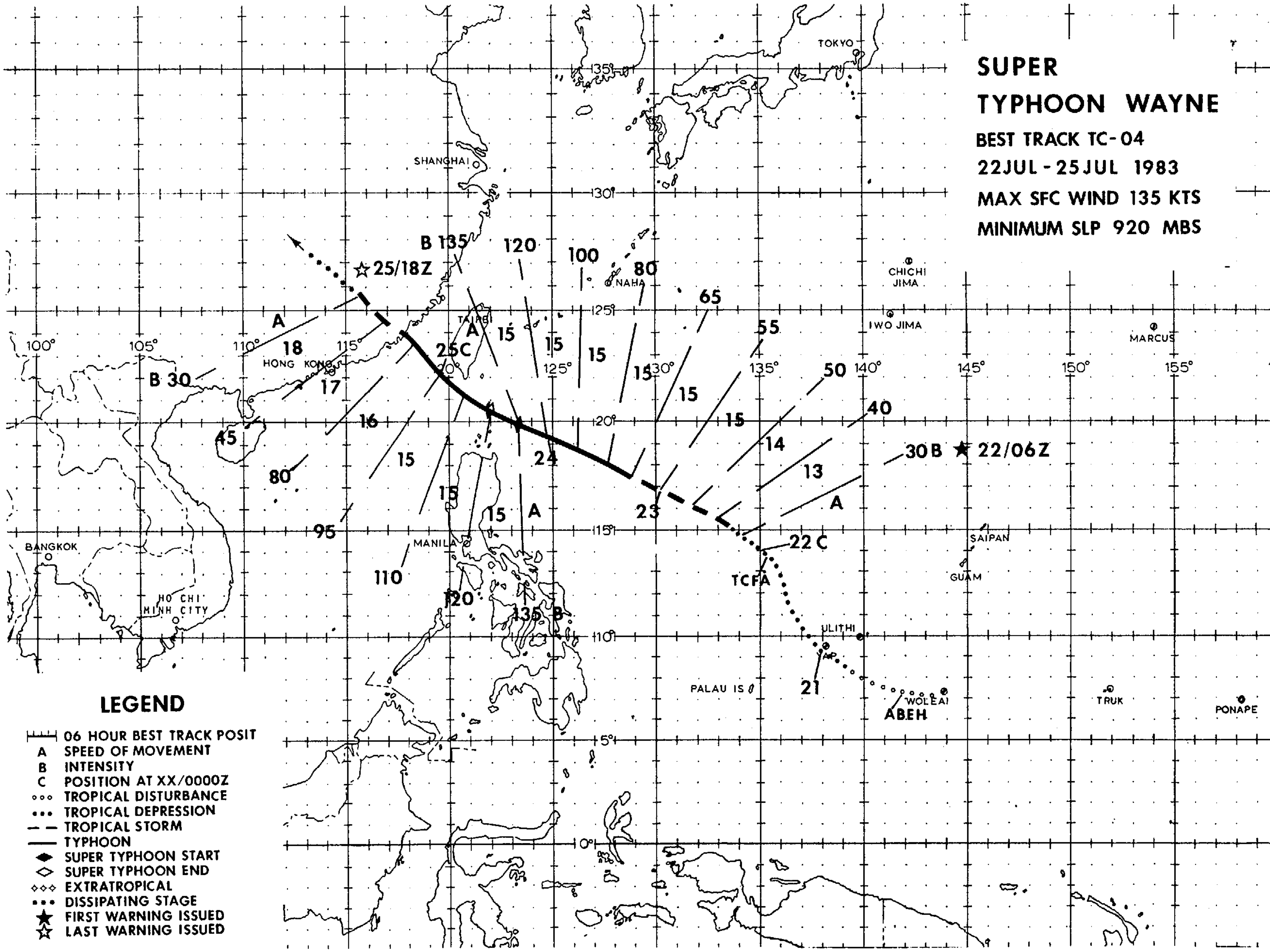


a. 48-HOUR 700mb PROG



b. 700mb ANAL

Figure 3-03-3. NOGAPS 48-hour 700 mb prog (a) and verifying analysis (b) valid for 161200Z. Track forecasts toward southern China were influenced by a series of numerical progs which indicated that a pronounced southerly flow would develop in the middle and lower levels over the South China Sea.


SUPER
TYPHOON WAYNE
BEST TRACK TC-04
22JUL-25JUL 1983
MAX SFC WIND 135 KTS
MINIMUM SLP 920 MBS
LEGEND
06 HOUR BEST TRACK POSIT
A SPEED OF MOVEMENT
B INTENSITY
C POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
DISSIPATING STAGE
FIRST WARNING ISSUED
LAST WARNING ISSUED
TOKYO
SHANGHAI
NAHA
CHICHI JIMA
IWO JIMA
MARCUS
TAIPEI
HONG KONG
MANILA
BANGKOK
HO CHI MINH CITY
SAIPAN
GUAM
ULITHI
PALAU IS
WOLEAI
TRUK
PONAPE
ABEH
TCFA
☆25/18Z
★22/06Z
22 C
21
23
24
25C
30B
B 135
B 30
135 B

Cyclogenesis of Super Typhoon Wayne began in an elongated east-west surface trough west of Truk (WMO 91334). Initial satellite imagery on 19 July at 1200Z indicated a widespread area of poorly organized convective activity supported by a weak upper-level anticyclone. This area remained poorly developed until 1200Z on the 21st when satellite imagery indicated the development of an upper trough northwest of the system (Figure 3-04-1). This served to support the development of the upper-level anticyclone. Subsequent satellite imagery indicated an increase in the organization and convective activity of the system. Based on this evidence and the potential for further development, a TCFA was issued at 212130Z. Initial aircraft reconnaissance at 220457Z revealed a weak tropical depression with an MSLP of 1005 mb and maximum surface winds of 25 kt (13 m/s). The first warning on Wayne was issued shortly thereafter at 220630Z.

During the next 24 hours, Wayne more than doubled in intensity to 65 kt (32 m/s) and began to track northwestward at 15 kt (26 km/hr). Aircraft reconnaissance at 230830Z reported very high 700 mb heights just prior to entering the eyewall of Wayne, followed by an extremely sharp pressure gradient on penetration to the center of the system. Wayne continued to intensify rapidly, again doubling in intensity over a 24 hour period as it moved westward along the southern periphery of the subtropical ridge. Maximum intensity of 135 kt (67 m/s) occurred at 240600Z only two days after the first warning on the system as a 25 kt (13 m/s) tropical depression.

Wayne's rapid intensification is evident in Figure 3-04-2. Note the generally good agreement between Dvorak intensity estimates and those from reconnaissance aircraft. Figure 3-04-3 shows Wayne near maximum intensity with a wall-developed anticyclone and gravity waves evident in the cloud features near the eye.

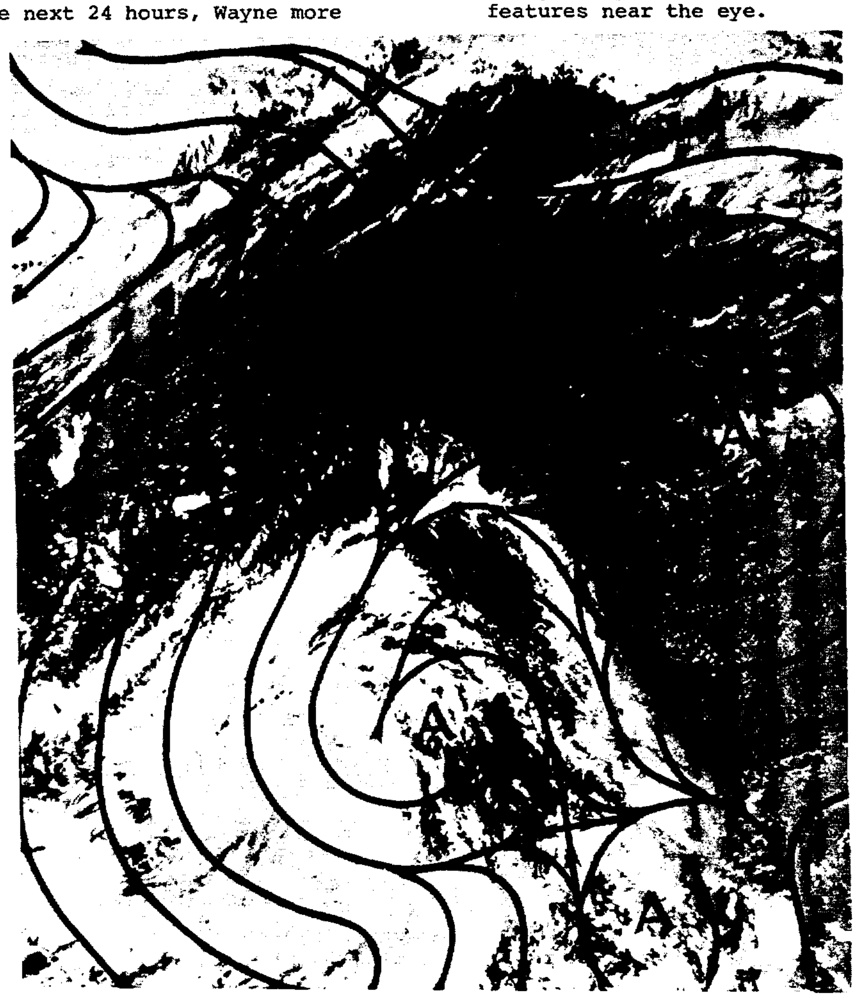


Figure 3-04-1. Overlay of 200 mb analysis with satellite imagery during early stages of development of Super Typhoon Wayne (212039Z July DMSP infrared imagery).

As Super Typhoon Wayne passed north of Luzon, the low-level surface flow was disrupted north of the storm by the topography of Taiwan, setting up a leeside trough in the Formosa Straits. Wayne responded to this trough, taking a more northward track and making landfall approximately 300 nm (556 km) east of Hong Kong (WMO 45005). Wayne struck the coast of China with typhoon strength, but rapidly dissipated as it moved inland over the mountainous terrain of southeastern China.

JTWC was successful in forecasting Wayne's track westward, but encountered problems forecasting speed of movement, which averaged 15 kt (26 km/hr), and intensity, which went from 25 kt (13 m/s) to 135 kt (67 m/s) in just 48 hours. Wayne's rapid intensification was a product of the supportive upper-level conditions which existed throughout its lifetime. Wayne's initial favorable position with respect to upper-level features (5-7 degrees southeast of a TUTT cell), was maintained throughout its westward track resulting in the development of well defined outflow channels to the northeast and southwest.

Although Wayne did not make landfall in the Philippines, high winds and torrential rainfall associated with its peripheral circulation brough destruction to areas far removed from the center. At least twenty people were killed and more than one hundred were reported missing when a bridge collapsed 300 nm (556 km) southeast of Manila (WMO 98426).

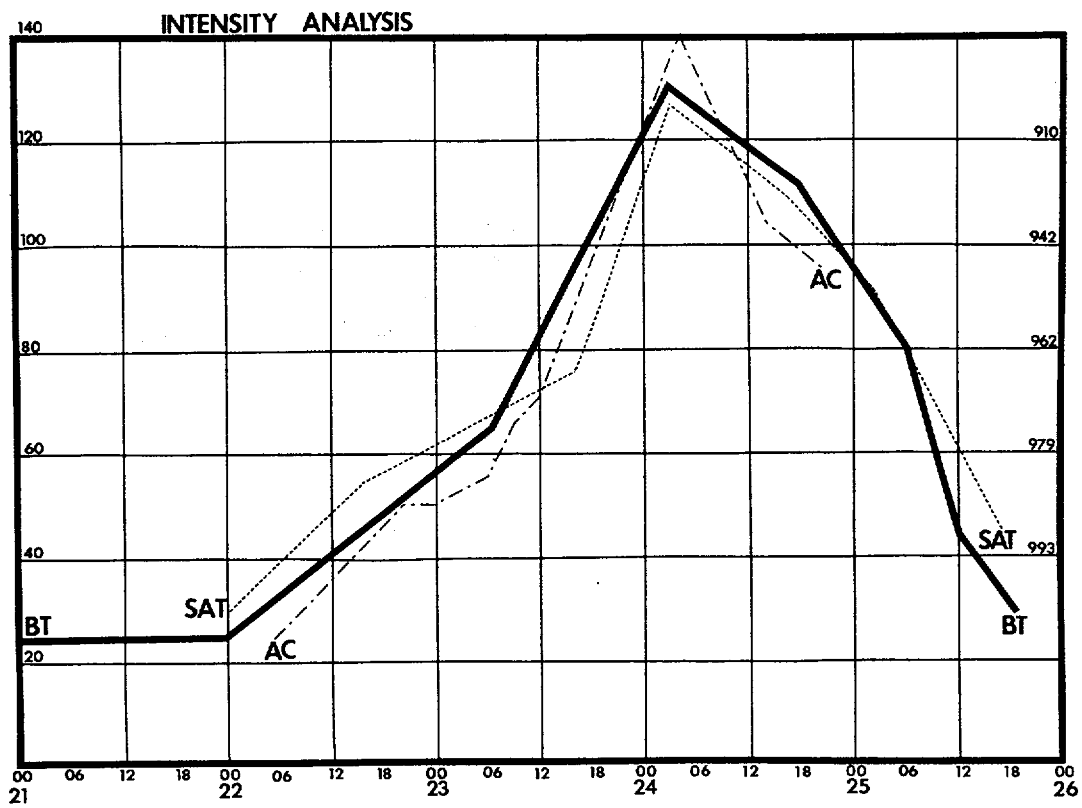
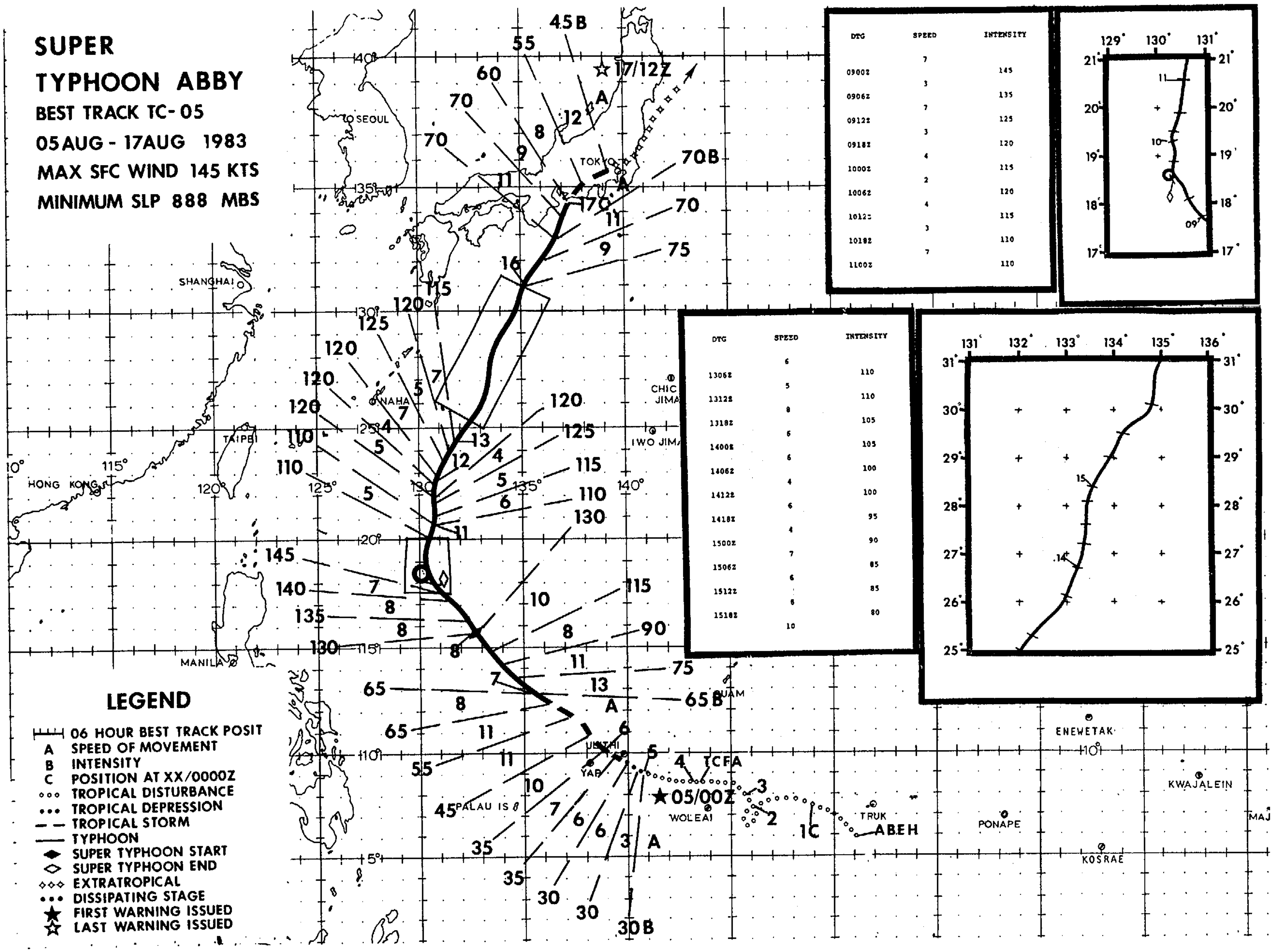


Figure 3-04-2. Satellite intensity estimates (Dvorak, 1973) and intensities measured by reconnaissance aircraft. Best track intensities are represented as a continuous line.

Figure 3-04-3. Super Typhoon Wayne at maximum intensity - 135 kt (67 m/s).



DTG	SPEED	INTENSITY
	7	
0900Z		145
	3	
0906Z		135
	7	
0912Z		125
	3	
0918Z		120
	4	
1000Z		115
	2	
1006Z		120
	4	
1012Z		115
	3	
1018Z		110
	7	
1100Z		110

DTG	SPEED	INTENSITY
	6	
1306Z		110
	5	
1312Z		110
	8	
1318Z		105
	6	
1400Z		105
	6	
1406Z		100
	4	
1412Z		100
	6	
1418Z		95
	4	
1500Z		90
	7	
1506Z		85
	6	
1512Z		85
	8	
1518Z		80
	10	

The tropical disturbance which eventually developed into the second super typhoon of the season was first detected on satellite imagery on 31 July as an area of enhanced convective activity to the southeast of Guam. This disturbance was located near 6N 152E in close proximity to an upper-level anticyclone. Surface data indicated that a weak surface circulation was centered approximately three degrees to the north of the area of convection. Over the next nine days, this circulation developed into an intense super typhoon with maximum sustained winds of 145 kt (75 m/s) and a massive circulation which was the dominant synoptic feature in the western Pacific. Abby's huge circulation system provided the environment for the development of a second tropical system (Tropical Storm Ben), and eventually caused the dissipation of Ben and another tropical storm (Carmen).

The first four days of Abby's development were unimpressive. The disturbance was monitored closely during this period as it moved slowly westward south of Guam. Although diurnal variations in the convective pattern associated with the disturbance made it appear at times that the system was becoming better organized, no consistent increase in organization was apparent until 3 August. At 2300Z on 3 August, a TCFA was issued for an area to the south-southwest of Guam based on the consistent increase in organization of the system observed on satellite imagery. A weather reconnaissance aircraft was launched soon after the TCFA was issued, but it was unable to close off a surface circulation even though several hours were spent investigating the suspect area. The mission did succeed in locating a circulation at flight level (1500 ft - 457 m), and at the 700 mb level.

The second aircraft reconnaissance mission was able to close off a surface circulation the following morning at 050034Z. Maximum sustained winds observed were 30 kt (15 m/s) and the MSLP was 1004 mb. On the basis of this report, the first warning was issued on the system as a tropical depression. The forecast called for continued movement towards the west-northwest with slow intensification.

Initial expectations proved reliable for the first 24 hours in warning status. The system was upgraded to a tropical storm at 050600Z on the basis of an increase in convective organization apparent from satellite imagery. At 060000Z Abby's intensity and position were close to forecast expectations.

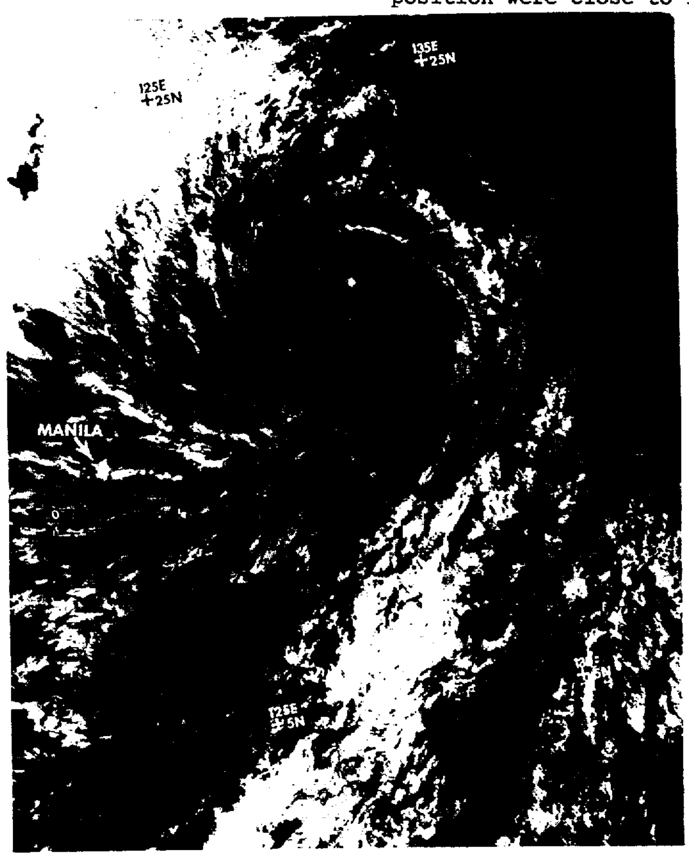


Figure 3-05-1. Super Typhoon Abby near maximum intensity (090946Z August DMSP infrared imagery).

Abby started to move on a more northwestward track after 060000Z, even though all JTWC forecast aids were indicating west-northwestward movement. This was a problem that persisted for the next 11 days. Abby continually tracked to the right of JTWC forecasts even though the forecast aids and numerical progs were all consistently in good agreement on a west-northwestward track for Abby.

Intensity forecasting also proved to be difficult. Initial expectations were quite accurate for the first 48 hours in warning status. As expected, Abby was upgraded to typhoon at 061800Z when satellite imagery indicated the presence of a weakness in the central dense overcast. The presence of an eye and the accuracy of the intensity estimate by satellite were confirmed five hours later by reconnaissance aircraft reports of 65 kt (33 m/s) winds and MSLP of 973 mb.

On the 7th of August, Abby began to intensify rapidly, far exceeding initial forecast expectations. Reconnaissance aircraft at 071141Z reported a MSLP of 946 mb, a decrease of 27 mb in approximately 12 hours. Other data (MSLP and equivalent potential temperature relationships (Dunnavan, 1981)) collected on the aircraft reconnaissance mission indicated that Abby was about to undergo rapid intensification. The 071200Z warning called for continued rapid intensification on the basis of this information. This forecast proved to be accurate as Abby continued to intensify rapidly over the next 30 hours reaching 120 kt (62 m/s) intensity within 12 hours and maximum intensity of 145 kt (75 m/s) at 081800Z. Abby's lowest central pressure was recorded at 082049Z when dropsonde data from reconnaissance aircraft indicated a measurement of 888 mb. Figure 3-05-1 shows Abby near maximum intensity. Except for minor fluctuations, Abby's intensity decreased slowly and steadily from this point on.

This decrease in intensity was accompanied by a decrease in forward speed as Abby began a slow northward movement for the next two and one-half days. JTWC forecasts for this two and one-half day period called for slow movement to the north followed by a turn to the northwest toward the island of Okinawa. This forecast track was supported by the FLENUMOCEANCEN numerical prog series which indicated that the subtropical ridge over southern Japan would strengthen and induce a northwestward movement. An example

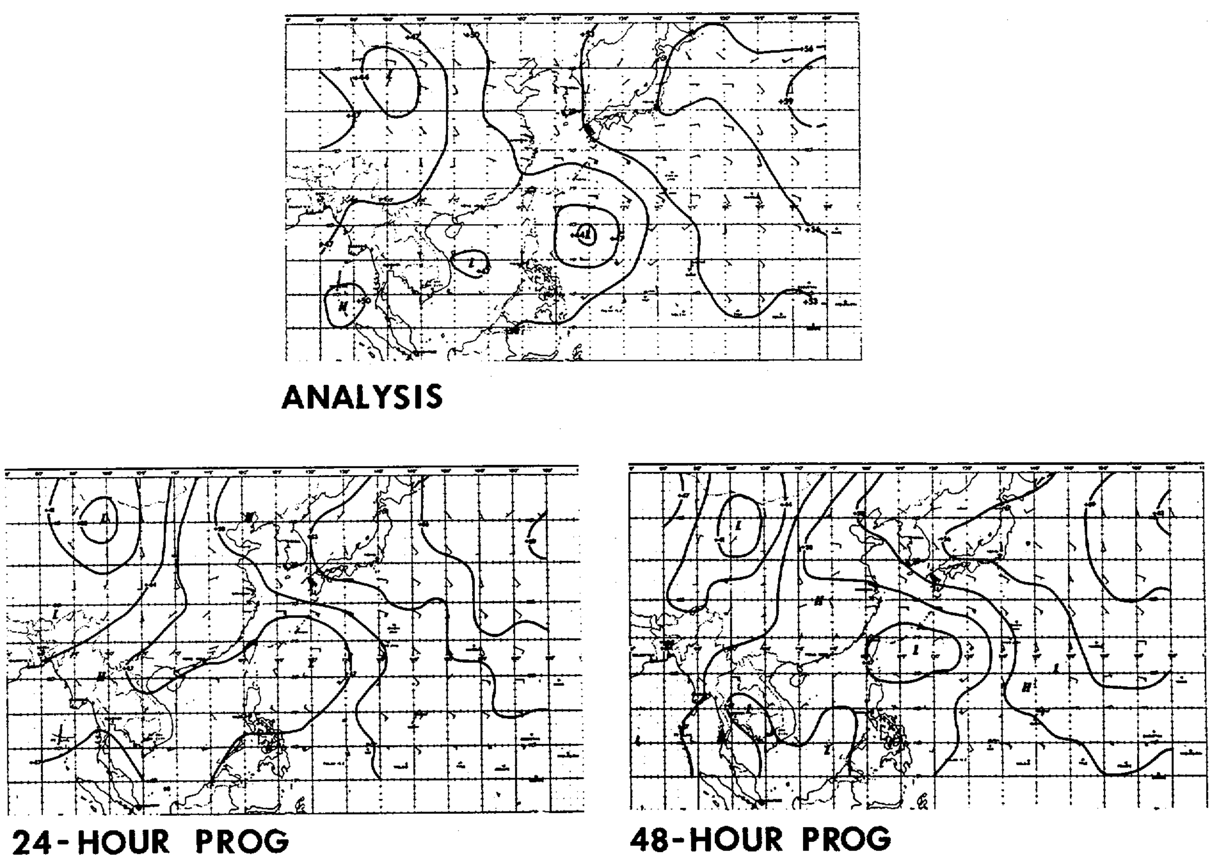


Figure 3-05-2. FLENUMOCEANCEN prog series for 850 mb at 091200Z August. Note that the subtropical ridge over Japan is forecast to remain as a block to northeastward movement.

of the prog series can be seen in Figure 3-05-2 which depicts the 850 mb prog series for 091200Z.

The intensification of the subtropical ridge over Japan that was consistently forecast in the prog series never occurred. An extensive post-analysis of the height fields over Japan and the islands to the south of Japan indicated that the subtropical ridge weakened continuously in this area over the eight day period following the analysis in Figure 3-05-2.

On the 12th of August, Abby began moving northeastward toward Honshu. Also on the 12th, two other tropical systems developed in the western Pacific; Tropical Storm Carmen (06W) in the South China Sea west of Luzon, and Tropical Storm Ben (07W) to the east of Abby near 26N 146E. The interaction of Abby's outflow with a TUTT cell to the northeast created an area of intense upper-level divergence under which Ben formed. The presence of both of these smaller systems had little effect on Abby, except for drawing some of the inflow away; but in the end, it was Abby which led to the demise of both Ben and Carmen when they became embedded in Abby's massive circulation.

As Abby continued its movement towards the northeast, the forecast emphasis changed from a northwest movement to that of a north-northwest movement towards the island of Kyushu. This forecast track was based on the strengthening of the subtropical ridge to the north and east of Abby; but as stated earlier, the ridge did not strengthen and Abby continued to move toward the northeast and weaken slowly. Aircraft reconnaissance data at 141035Z indicated that Abby's central pressure had risen to 942 mb and that the eyewall was beginning to deteriorate. Abby's intensity fell below 100 kt (51 m/s) at 141800Z for the first time in 7 days.

Abby continued moving to the northeast on the 15th of August with a slight increase in forward speed. Application of an objective technique for predicting acceleration (Weir, 1982) led to a forecast of rapid acceleration to the north through central Japan and extratropical transition over the Sea of Japan. This was based on the expectation that Abby would come under the influence of strong southerly flow in advance of a major trough over northern China. The predicted acceleration never materialized as an upper-level ridge developed over the Sea of Japan to the northwest of Abby (Figure 3-05-3) and effectively blocked this interaction.

Japanese weather radar stations started fixing Abby after 160000Z, with all of the fixes showing continued northeast movement. Data from reconnaissance aircraft, satellite imagery, and synoptic reports indicated that Abby was weakening as it underwent extratropical transition. Abby was downgraded to tropical storm at 170000Z and soon after made landfall near Hamamatsu Japan (WMO 47654). After making landfall, Abby moved eastward following the rugged terrain toward Tokyo, weakening rapidly as it interacted with the mountains. At 171200Z, satellite imagery and synoptic data indicated that Abby had completed extratropical transition, and the final warning by JTWC was issued.

Abby's movement through central Japan caused serious damage over a widespread area. Initial reports indicated that at least two people were killed, 29 others were injured, and one person was missing. The torrential rains generated by Abby resulted in widespread flooding, causing numerous landslides and the destruction of 19 bridges. The heavy rains also severely disrupted road, rail, sea and air service in central Japan.

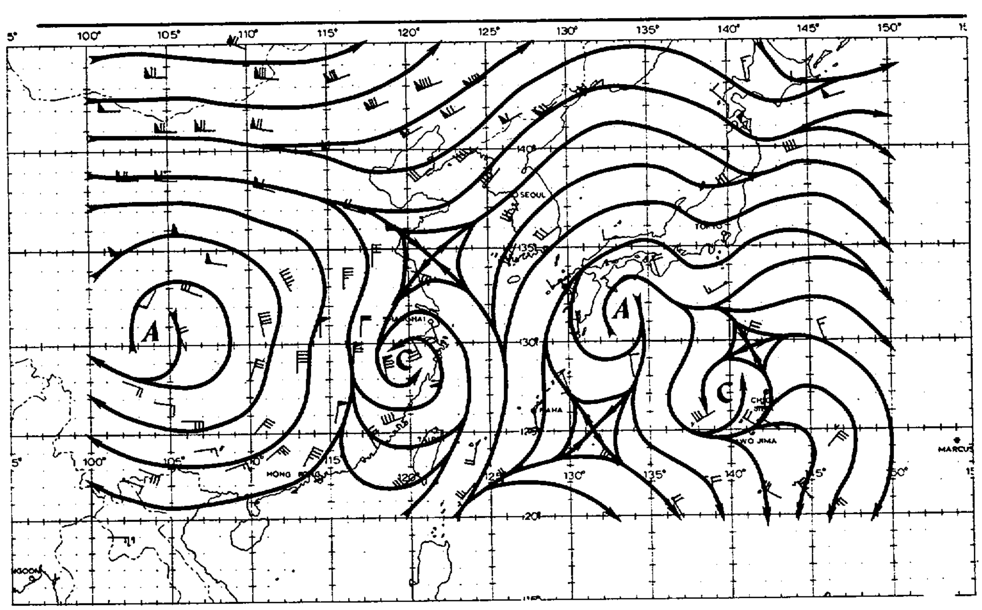
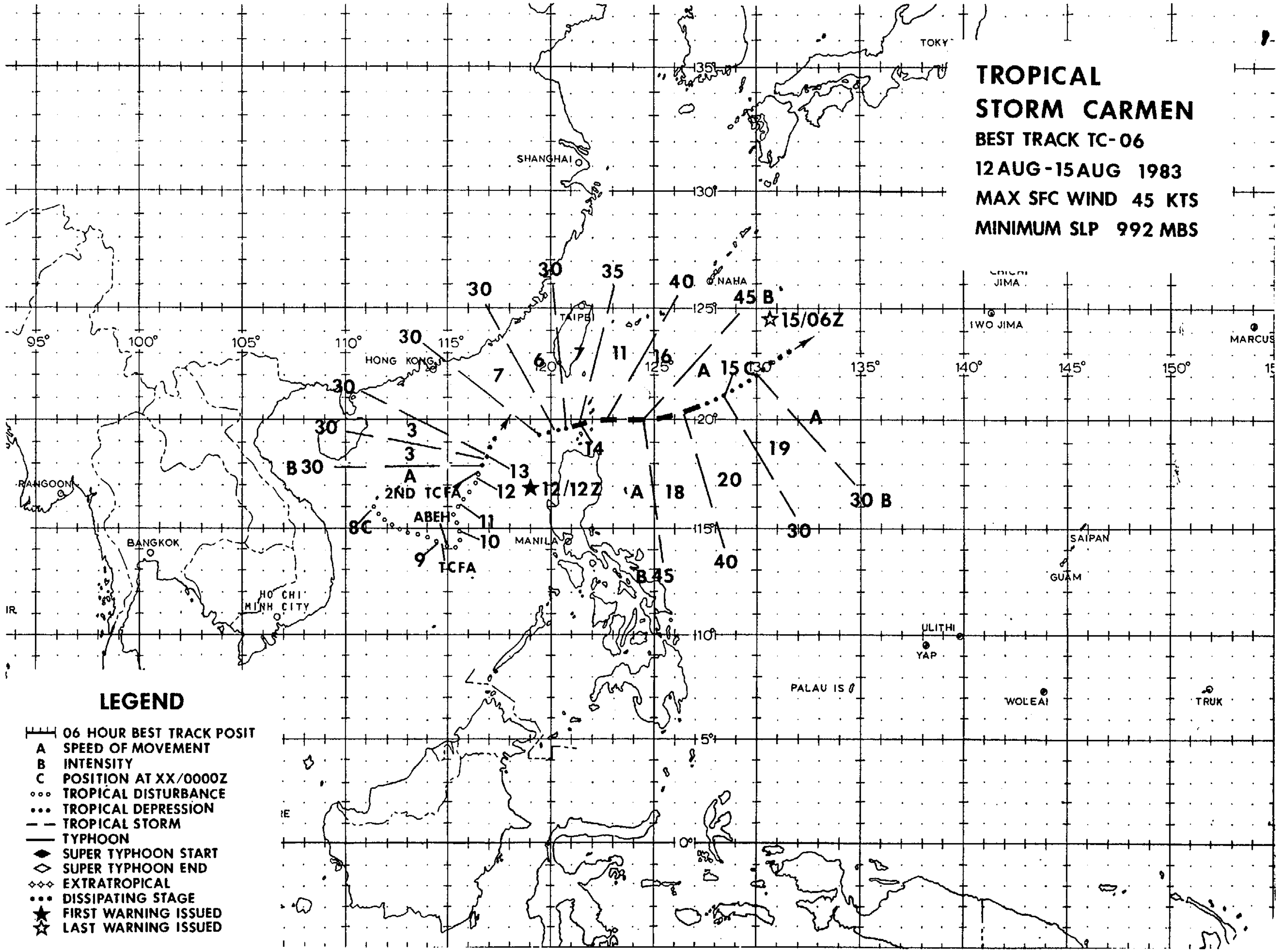


Figure 3-05-3. 200 mb analysis for 170000Z August showing the ridge over the Sea of Japan which prevented Abby from interacting with the westerlies and accelerating northeastward.


TROPICAL STORM CARMEN
BEST TRACK TC-06
12AUG-15AUG 1983
MAX SFC WIND 45 KTS
MINIMUM SLP 992 MBS
LEGEND
06 HOUR BEST TRACK POSIT
A SPEED OF MOVEMENT
B INTENSITY
C POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
DISSIPATING STAGE
FIRST WARNING ISSUED
LAST WARNING ISSUED
12/12Z
15/06Z
2ND TCFA
TCFA
ABEH
SHANGHAI
TAIPEI
NAHA
HONG KONG
MANILA
BANGKOK
RANGOON
HO CHI MINH CITY
IWO JIMA
MARCUS
SAIPAN
GUAM
ULITHI
YAP
PALAU IS
WOLEAI
TRUK

Tropical Storm Carmen had its origins in the monsoon trough which was well established over Southeast Asia and moved into the South China Sea in early August. A low level circulation first located about 200 nm (370 km) east of Vietnam persisted as a closed circulation on the surface streamline analysis and as an area of enhanced convective activity on satellite imagery for several days while moving slowly eastward along the trough axis. At the same time, Super Typhoon Abby was undergoing rapid intensification in the Philippine Sea. Abby's outflow generated a strong easterly flow at upper-levels which was expected to inhibit the development of the tropical disturbance in the South China Sea. However, on 9 August, satellite imagery at 0000Z indicated that outflow was developing over the South China Sea disturbance. Synoptic data also indicated that the low-level circulation had become better organized and had associated surface winds of 20 kt (10 m/s) and an MSLP of 1002 mb. This increase in organization prompted the issuance of a TCFA at 090300Z.

The disturbance remained in alert status for the next three days as it tracked slowly north-northeastward with little change in intensity. Aircraft reconnaissance at 120247Z indicated that the disturbance was still poorly organized with an MSLP of 1000 mb. Satellite imagery during this period also indicated little increase in convective organization. At 120900Z, satellite imagery indicated that the disturbance had developed a small central convective feature. The initial warning for Carmen as a tropical depression was issued at 121200Z on the basis of this increase in convective organization.

For the rest of the day, Carmen tracked slowly north-northeastward without any further development in convective organization. Suddenly, between 130000Z and 130600Z, the depression appeared to rapidly accelerate from 3 to 26 kt (2-13 m/s) and move east-northeastward toward the Luzon Straits. Warnings at the time reflected this rapid acceleration. However, in post-analysis, satellite imagery indicated the presence of several weak circulations (eddies) near the Luzon Straits during this period. A new circulation established itself 70 nm (130 km) to the northwest of Luzon, approximately 170 nm (315 km) east of Carmen. It was this new circulation that was tracked from 130600Z onward as Carmen. The disturbance that was initially designated Carmen, continued its north-northeastward track and persisted as a small area of convection for another 18 hours before eventually dissipating over water on 14 August. The new disturbance that was now designated Carmen, moved east-northeastward through the Luzon Straits, embedded in the low-level flow feeding into Super Typhoon Abby in the Philippine Sea. In spite of the hostile shearing environment and the fact that the depression was embedded in Abby's inflow, intensification of this circulation continued and upgrade to tropical storm occurred on the 131800Z warning.

Carmen continued to intensify, reaching maximum intensity of 45 kt (23 m/s) at 141200Z while accelerating toward Abby. Figure 3-06-1 shows Carmen near maximum intensity 100 nm (185 km) northeast of Luzon. Less than 12 hours later, at 142300Z, Carmen was almost completely absorbed into Abby's circulation and was no longer "fixable" by reconnaissance aircraft.

The final warning on Carmen, now a tropical depression, was issued on the 15th at 0600Z when it became impossible to identify the remnants of the system on satellite imagery.

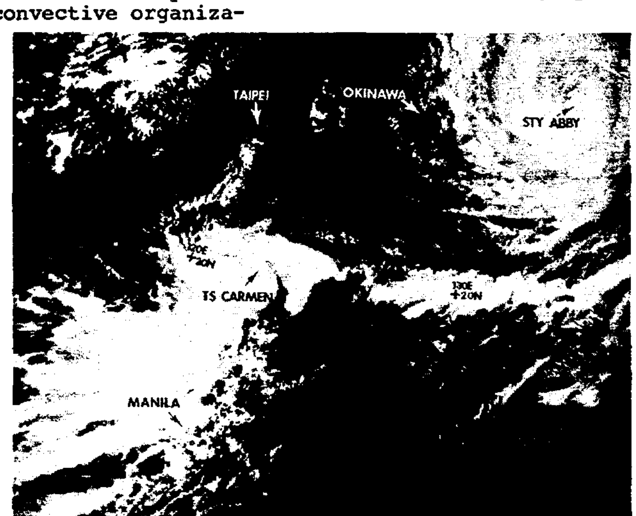
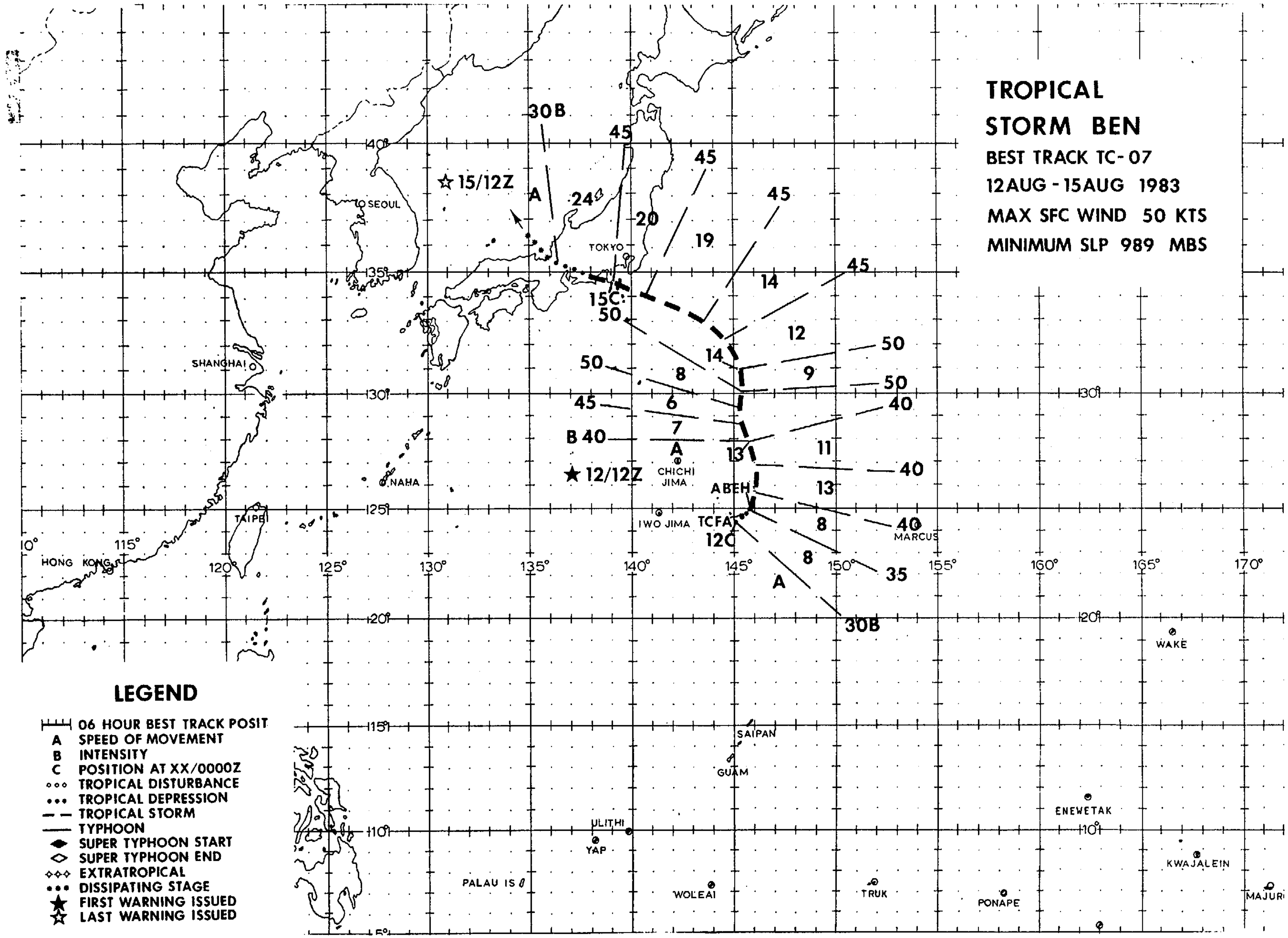


Figure 3-06-1. Tropical Storm Carmen near maximum intensity 100 nm (185 km) northeast of Luzon. Super Typhoon Abby (upper right) completely absorbed Carmen into its circulation less than a day later (140632Z NOAA 7 visual imagery).


TROPICAL
STORM BEN
BEST TRACK TC-07
12AUG-15AUG 1983
MAX SFC WIND 50 KTS
MINIMUM SLP 989 MBS
LEGEND
06 HOUR BEST TRACK POSIT
A SPEED OF MOVEMENT
B INTENSITY
C POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
DISSIPATING STAGE
FIRST WARNING ISSUED
LAST WARNING ISSUED
☆ 15/12Z
★ 12/12Z
15C
12C
TCFA
ABEH
30B
SEOUL
TOKYO
SHANGHAI
TAIPEI
HONG KONG
NAHA
CHICHI JIMA
IWO JIMA
MARCUS
WAKE
SAIPAN
GUAM
ULITHI
YAP
PALAU IS
WOLEAI
TRUK
PONAPE
ENEWETAK
KWAJALEIN
MAJURO

As Typhoon Abby approached Japan from the southwest, satellite imagery indicated that an area of intense convection was forming on the eastern periphery of its circulation (Figure 3-07-1). Surface and 200 mb analyses at the time (Figure 3-07-2 and 3-07-3) indicated that the convection was not associated with a separate surface circulation but with an area of highly divergent flow at upper-levels. This flow was associated with a TUTT cell located to the northeast of Abby.

This area of active convection persisted with no apparent associated low-level circulation until 12 August, when visual satellite imagery indicated the presence of a low-level circulation on the western edge of the convective activity. The presence of a surface circulation in an area of such strong upper-level divergence prompted the issuance of a TCFA at 120419Z.

Reconnaissance aircraft investigated this area later in the day and located a poorly defined circulation with a highly asymmetric wind field. Winds of 40 kt (21 m/s) were observed over a broad area in the southeastern semicircle of the circulation but winds to the north and west were in the 10-20 kt (5-10 m/s) range. The first warning for Tropical Storm Ben was issued at 121200Z and forecasted northwestward movement up the eastern coast of Japan at the periphery of the subtropical ridge. This forecast scenario appeared valid for the next 24 hours as Ben moved northward and turned westward as expected. However, westward motion was greater than originally forecast and Ben moved rapidly along the southern coast of Honshu prior to making landfall west of Hamamatsu (WMO 47654). As Ben moved westward, it entered an area of strong upper-level flow associated with outflow from Typhoon Abby. Satellite imagery indicated that the convection associated with Ben was dissipating and appearing at successively greater separation distances to the east of the low-level circulation center.

By 14 August, Ben was a completely exposed low-level circulation and remained so until dissipation in the Sea of Japan at 151200Z.

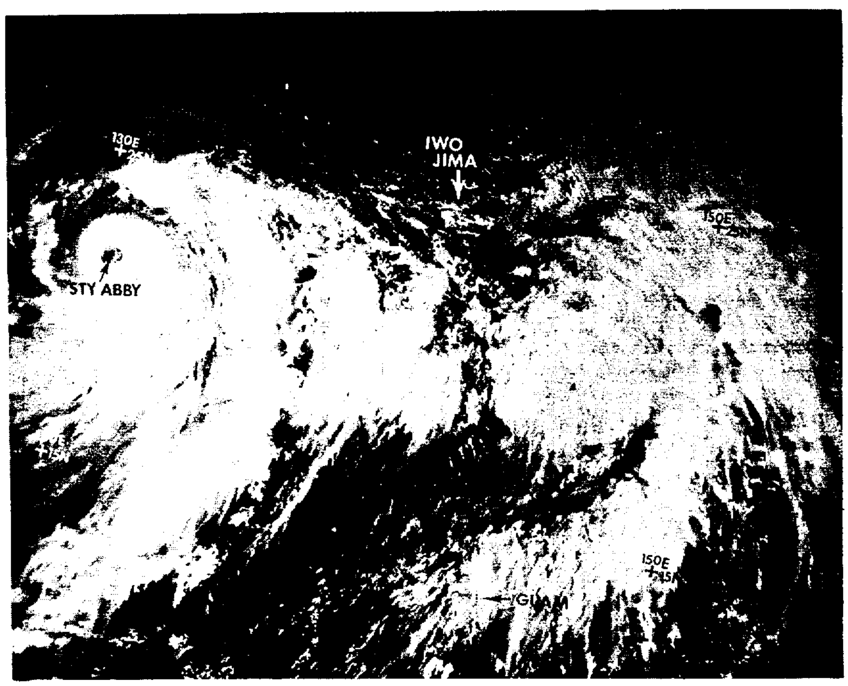


Figure 3-07-1. Typhoon Abby (left) and the area of enhanced convective activity to the east where Tropical Storm Ben formed. (110527Z NOAA 7 visual imagery).

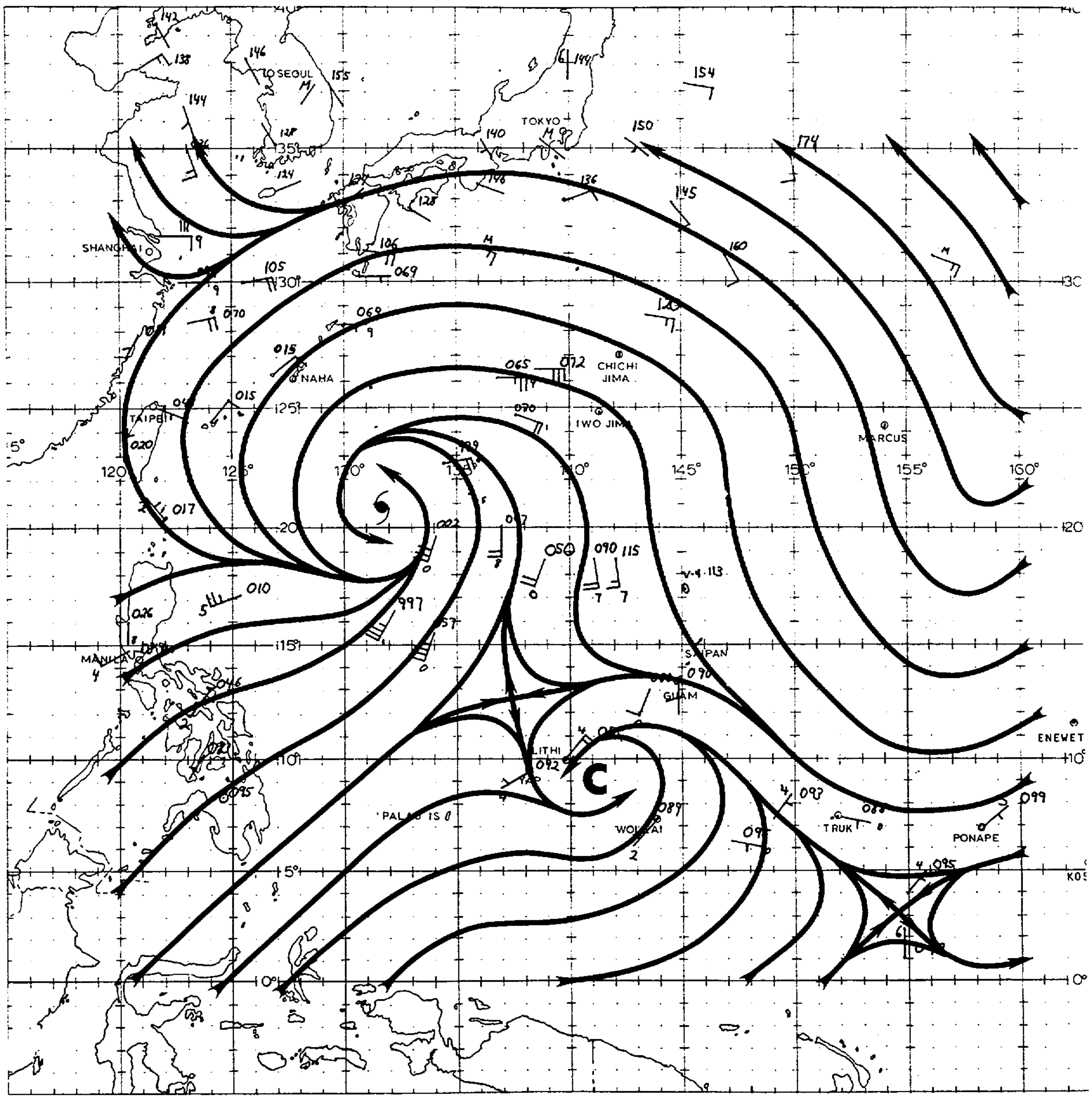


Figure 3-07-2. 110000Z surface analysis. Although analysis time corresponds closely with the time of the satellite picture shown in Figure 3-07-1, there is no indication of a surface circulation in the area where Ben formed 24 hours later.

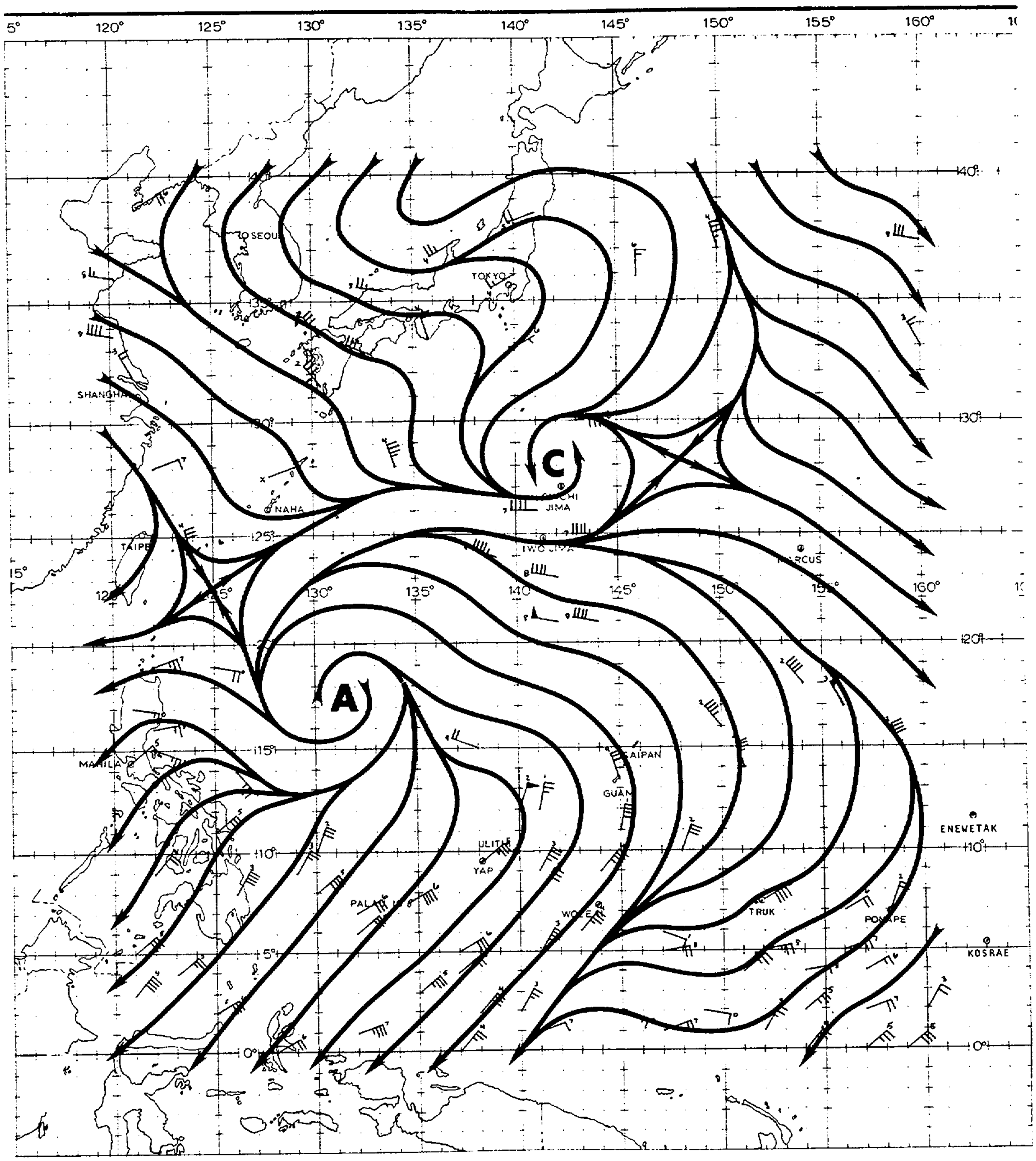
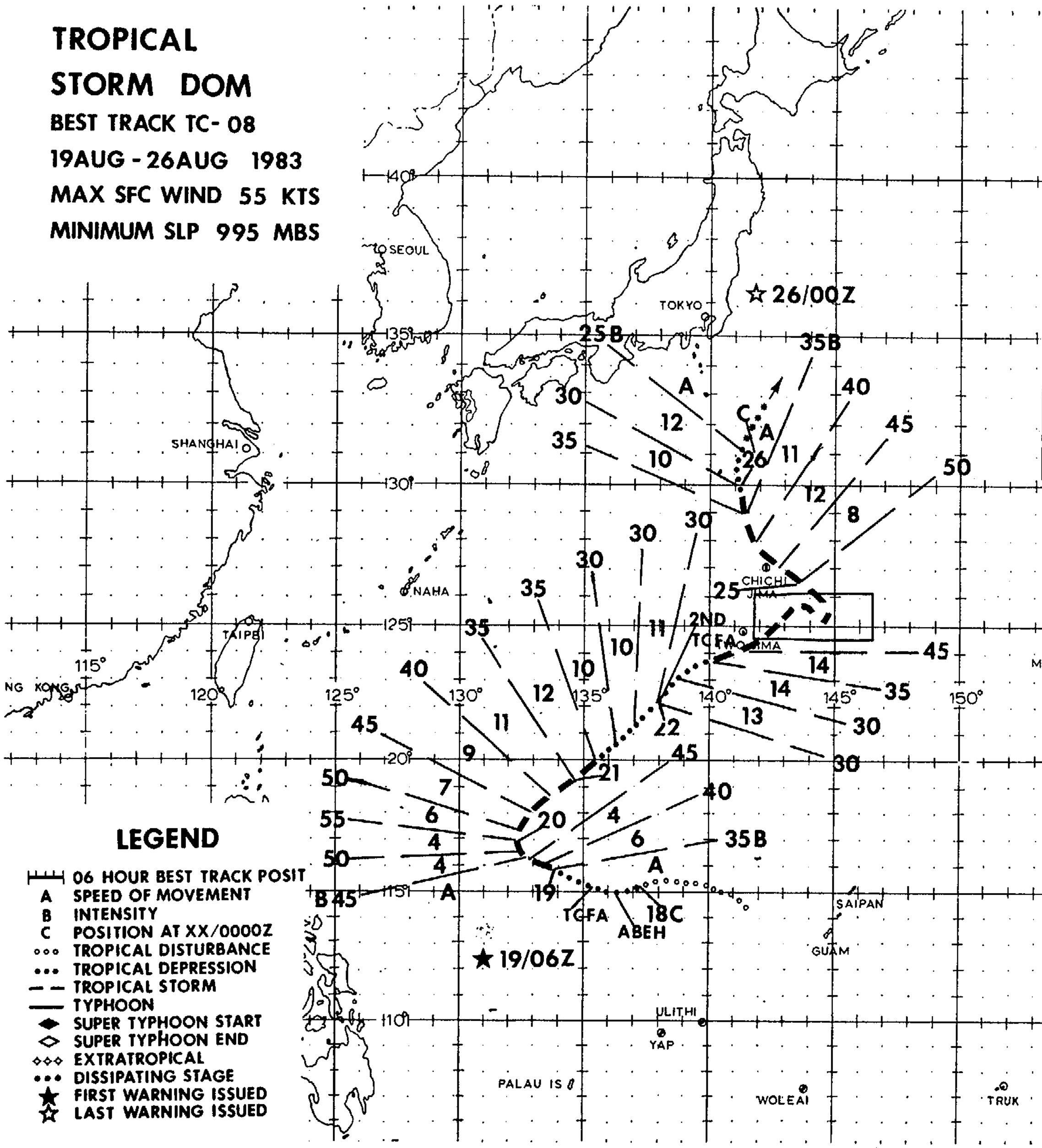
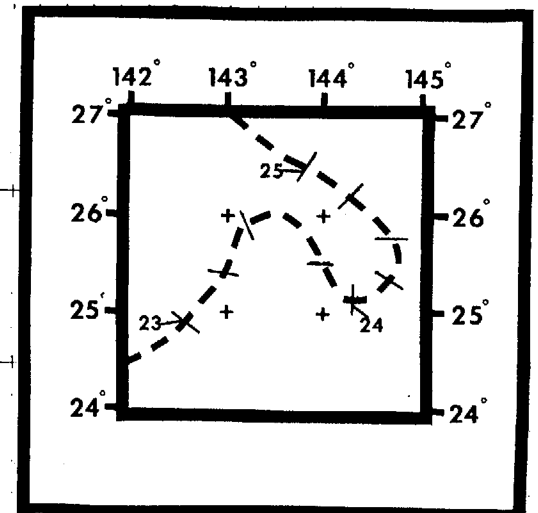


Figure 3-07-3. 110000Z 200 mb analysis. The area of enhanced convective activity to the east of Abby in Figure 3-07-1 corresponds to an area of highly divergent upper-level flow created by the interaction of Abby's outflow with a TUTT cell.

TROPICAL STORM DOM

BEST TRACK TC- 08
19AUG - 26AUG 1983
MAX SFC WIND 55 KTS
MINIMUM SLP 995 MBS





DTG	SPEED	INTENSITY
2300Z		50
	7	
2306Z		50
	5	
2312Z		45
	5	
2318Z		40
	5	
2400Z		40
	4	
2406Z		45
	5	
2412Z		50
	7	
2418Z		50
	7	
2500Z		50

Tropical Storm Dom developed from a disturbance which was initially detected west of Guam on 17 August. Over the 10 day period of its life, Dom underwent radical changes in track and intensity. These changes and Dom's lack of significant vertical development created difficulties for JTWC forecasters. Radical intensity changes resulted in a 36-hour period when no numbered tropical cyclone warnings were issued on Dom by JTWC (21-23 August).

As Super Typhoon Abby approached Tokyo on 17 August, low latitude wind regimes began to return to their seasonal mean locations. Figure 3-08-1 shows the orientation of the low-level monsoon and upper-tropospheric troughs on 17 August, as well as the climatological positions for each for the month of August. Of significance is the position of the low-level trough to the west of the upper-level trough, which was anchored to an intense upper-tropospheric cyclone near Guam. As this occurred, an area of strong upper-level divergence formed in the northeasterlies to the west of the upper-level cyclone and a convective disturbance developed within the low-level trough.

On 18 August, a reconnaissance aircraft investigated the disturbance at 700 mb and reported flight level winds of 25 kt (13 m/s) and an extrapolated MSLP of 999 mb. On the basis of this report and subsequent satellite imagery which indicated increased convective organization, a TCFA was issued at 181100Z. The next reconnaissance aircraft mission, at 190735Z, located a well defined surface circulation with an MSLP of 1004 mb and maximum sustained surface winds of 40 kt (21 m/s). The initial warning for Tropical Storm Dom was issued on receipt of this information from the aircraft.

During the two-day period prior to initial warning, Dom had tracked steadily westward at 9 kt (5 km/hr). In spite of this, continued westward movement was rejected by JTWC forecasters and Dom was forecast to move northward from the initial warning. Figure 3-08-2 shows the guidance available to JTWC forecasters from the objective forecasting techniques for the 191200Z warning (Note: objective techniques are originated from a preliminary best track position six hours prior to warning time - in this case 190600Z). Although there were considerable differences in the forecast aids, both dynamic models (NTCM and OTCM) predicted northward movement, reflecting the absence of a strong subtropical ridge. The Prognostic Reasoning Message (WDPA1 PGTW) which was issued following the 191200Z warning is the best summary of the situation.

> "Dom is forecast to turn northward during the next 24 hours. Low-level steering is predominately from south-to-north and the presence of middle-tropospheric westerlies north of 22N is seen as evidence of the overall weakness of the subtropical ridge over the Philippine Sea."
> "The most significant feature on the charts is a deep, complex low pressure area which extends eastward from Japan. The FLENUMOCEANCEN prognosis series maintains this mid-latitude trough throughout the forecast period. Its influence is expected to maintain the weakness in the ridge and allow Dom to move northward. Not forecast by the numerical prognoses, but considered possible, is an increase in the southwest monsoonal flow over the Philippine Sea. A linkage between the southwest monsoon and the mid-latitude trough, east of Japan, could cause Dom to track northeastward instead."

The alternate scenario proved correct, as Dom turned sharply northeastward on 20 August.

Throughout much of its life, Dom's low-level center was located northeast of its significant convection. Strong upper-level northeasterlies were exerting considerable pressure on the atmospheric column above Dom, resulting in the consistent tilt toward the southwest. The mission ARWO[1] on the 192330Z fix mission observed "The extremely slight pressure gradient indicated that this was probably a shallow tropical cyclone....the 700 mb center was located southwest, relative to the surface center, but even further displaced (from the earlier penetration). A solid "wall" of convective activity seemed to be developing at this time, extending through the southwest quadrants." This observation was made at Dom's peak intensity of 55 kt (28 m/s).

As Dom turned northeastward, the area of strongest convective activity became further separated from the surface center (Figure 3-08-3) and eventually weakened. On 21 August, reconnaissance aircraft verified the weakening of the system as observed on satellite imagery. Surface winds near the center were light and surface pressures were up significantly although stronger, near gale-force, winds were present 50 to 60 nm (93 to 111 km) southeast of the surface center, within the monsoonal flow. Since Dom was not expected to reintensify in such a hostile shearing environment, tropical cyclone warnings were suspended after the issuance of the 211200Z warning. In the

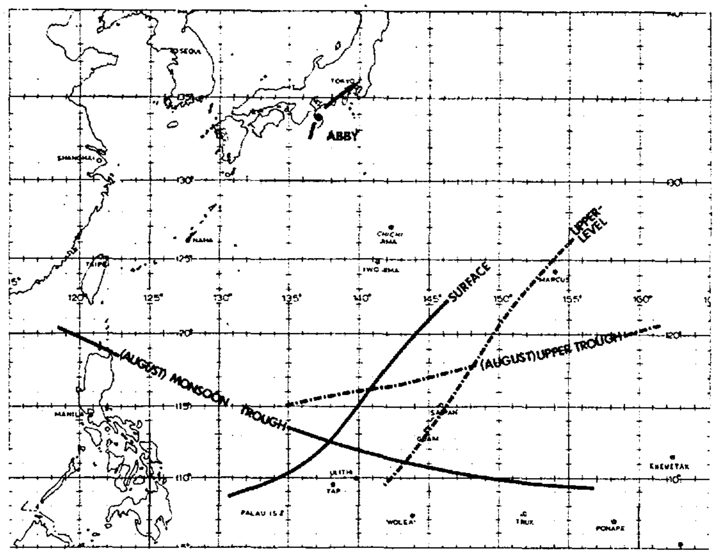


Figure 3-08-1. Location of the axis of the low-level and upper-level troughs on 17 August and the monthly climatological position of the monsoon (low-level) and tropical upper-tropospheric troughs for August. Note the northeast to southwest orientation of each trough on the 17th, and the atypical location of the low-level trough west of the upper-level trough.

subsequent 12 hours, satellite imagery indicated that convective activity was increasing near the center, prompting the issuance of a TCFA at 212330Z. An aircraft reconnaissance mission was flown at 220612Z and found 30 kt (15 m/s) surface winds more than 200 nm (370 km) southeast of a 1003 mb surface center. However, the next mission, at 222351Z found a 995 mb center with a 40 kt (21 m/s) maximum wind 10 nm (19 km) east of the surface center. On the basis of this report, Tropical Storm Dom was returned to warning status at 230000Z while the aircraft was still in the center. As the aircraft exited to the south, it encountered even stronger winds than those previously reported. The following was extracted from the ARWO's[2] post flight mission report:

> "This system continued to have a majority of its weather concentrated in the south....showers were very heavy and ominous looking, in fact, I observed a waterspout trailing from one of the heavier showers. Even though we were only 60 to 100 nm (111 to 185 km) from the center during the invest, we found light and variable winds, especially in the northern half of the storm. I was hard pressed to close off the circulation in the northwest quadrant. Once closed off, the storm showed itself to be a highly compact area of 40 kt (21 m/s) surface winds, extending 45 nm (83 km) from the center. The center itself was a small area, 3 to 5 nm (6 to 9 km), where the pressure dropped rapidly. This area of low pressure was very definite, but difficult to hit exactly due to its highly localized area. After the fix, we headed due south and, in a 30 nm (56 km) wide band beginning 20 nm (37 km) from the surface center, I observed surface winds reaching 50 kt (26 m/s) with gusts to 60 kt (31 m/s)."

Figure 3-08-4 shows Dom just prior to this aircraft mission.

During Dom's northeastward trek, its movement was correlated to the monsoon southwesterlies and a stationary mid-latitude trough located east of Japan. On 22 August, this trough, including the extratropical remains of Super Typhoon Abby (05W) began to move eastward and weaken. This change, along with a lessening of the influence of the upper-tropospheric northeasterlies over Dom, were contributing factors in Dom's reintensification. It also marked a change in steering influences which resulted in Dom moving erratically from 231200Z to 241200Z, prior to assuming a north-northwestward track. During this period, Dom's intensity dropped slightly, to 40 kt (21 m/s) but peaked again briefly as an upper-level anticyclone became established over the system (Figure 3-08-5). However, this upper-level support proved to be short-lived and Dom was reduced to an exposed low-level circulation of tropical depression intensity a day later.

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[1]Mission ARWO (Aerial Reconnaissance Weather Officer), 1Lt Gregory T. Marx, USAF.

[2]Mission ARWO, Capt Stephen W. Lizon, USAF.

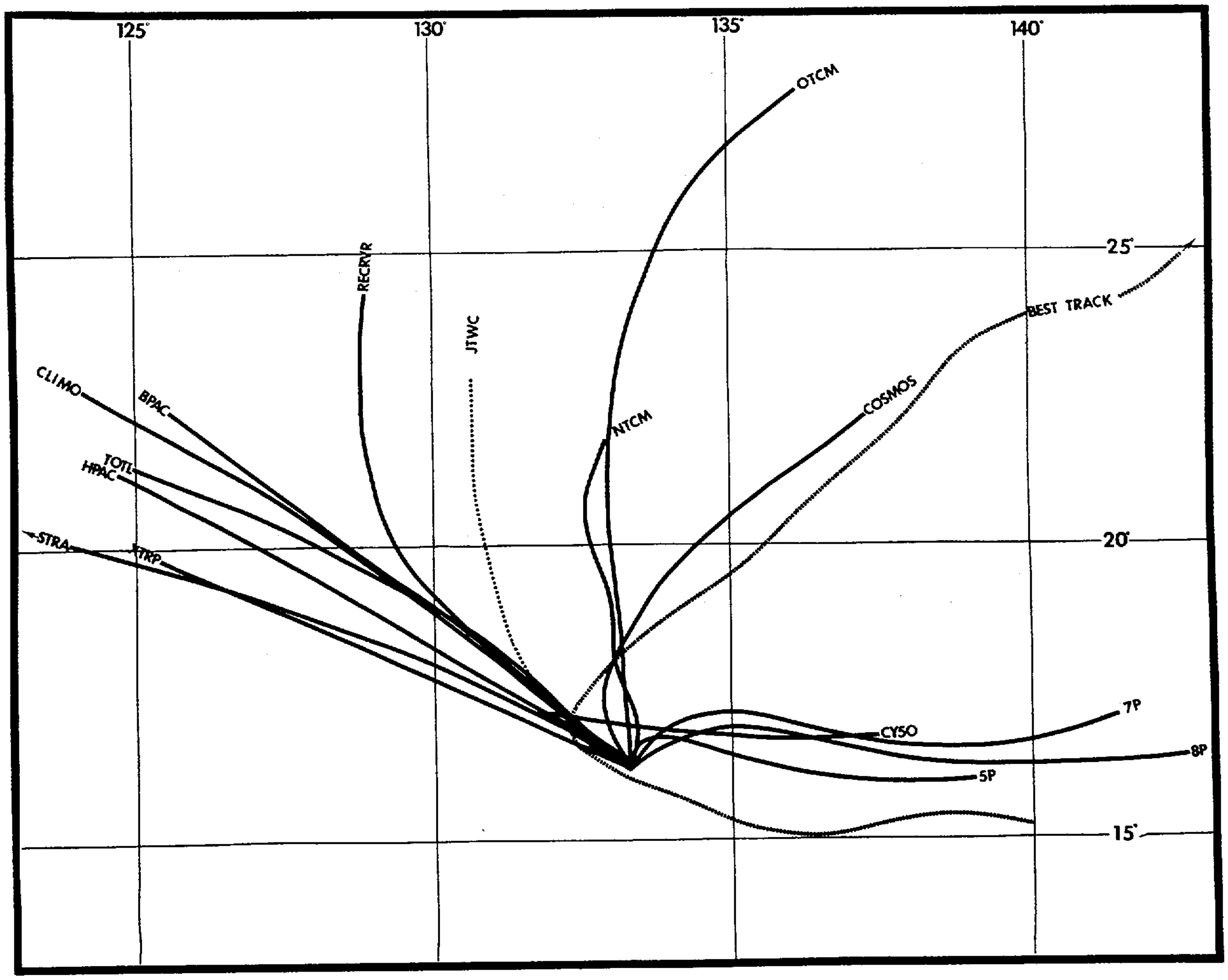


Figure 3-08-2. The standard array of JTWC's objective forecasting techniques available to support the 191200Z warning. Included is the forecast issued at 191200Z and the eventual best track. Note that the technique "COSMOS", currently under test and evaluation at JTWC, did a superior job in forecasting the eventual track.

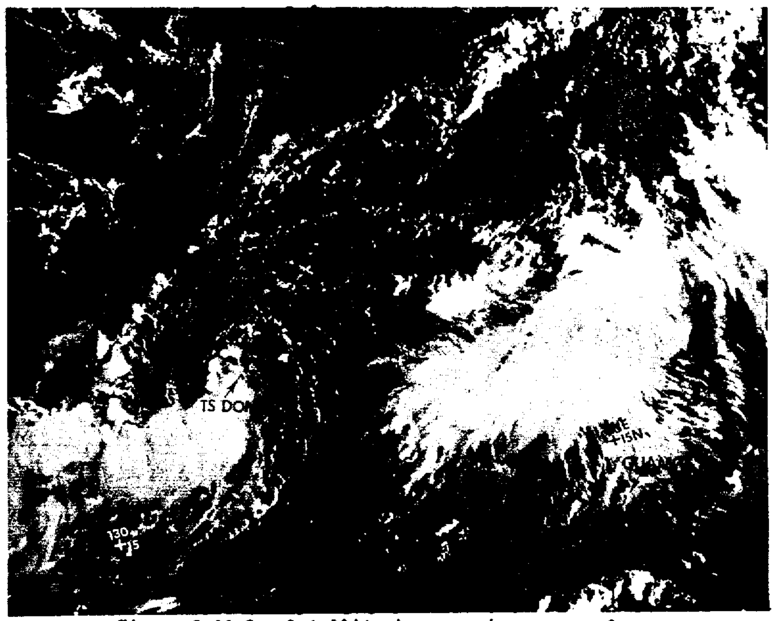


Figure 3-08-3. Satellite imagery shows several convective cells extending toward the southwest and west of Dom's low-level center (202234Z August NOAA 8 visual imagery).

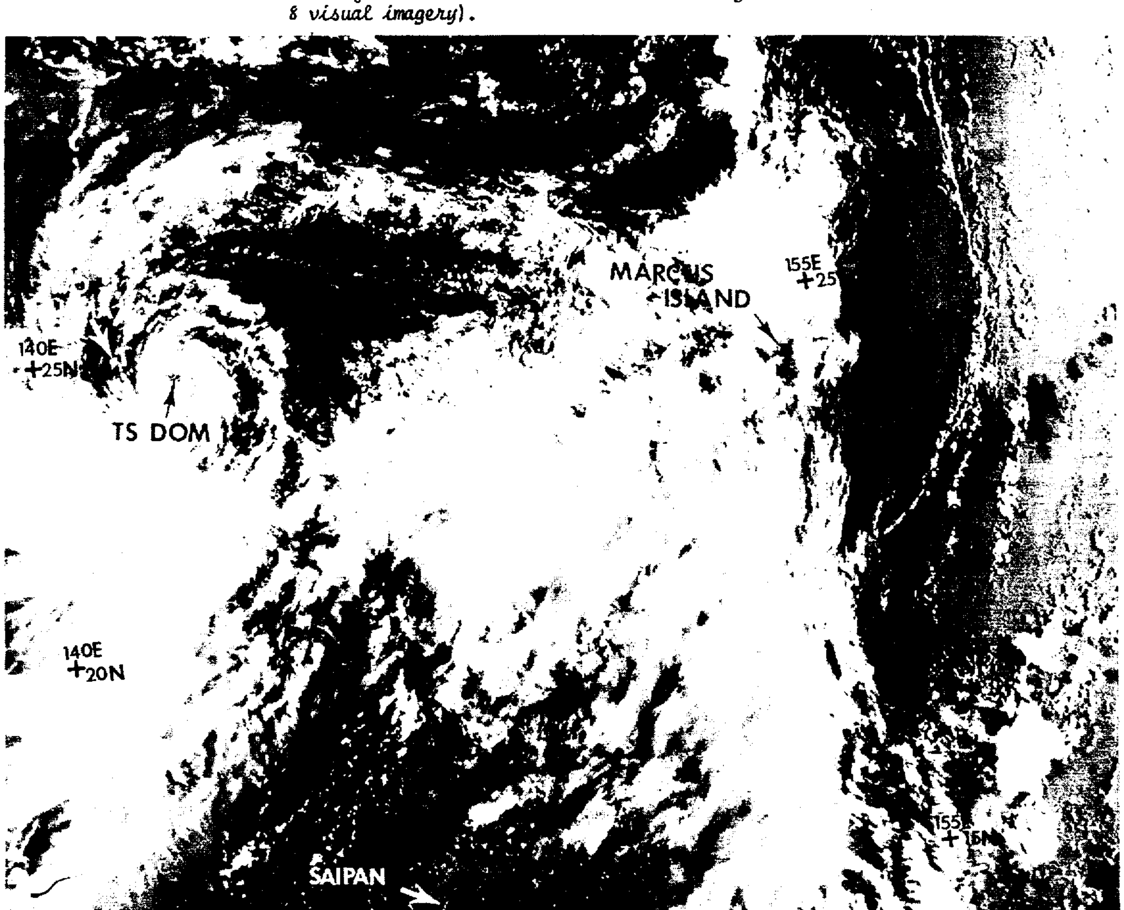


Figure 3-08-4. Satellite imagery received just prior to aircraft data indicates that the system had reintensified. Note the low-level cloud lines which correspond to the ARWO's description of the system (222150Z August NOAA 8 visual imagery).

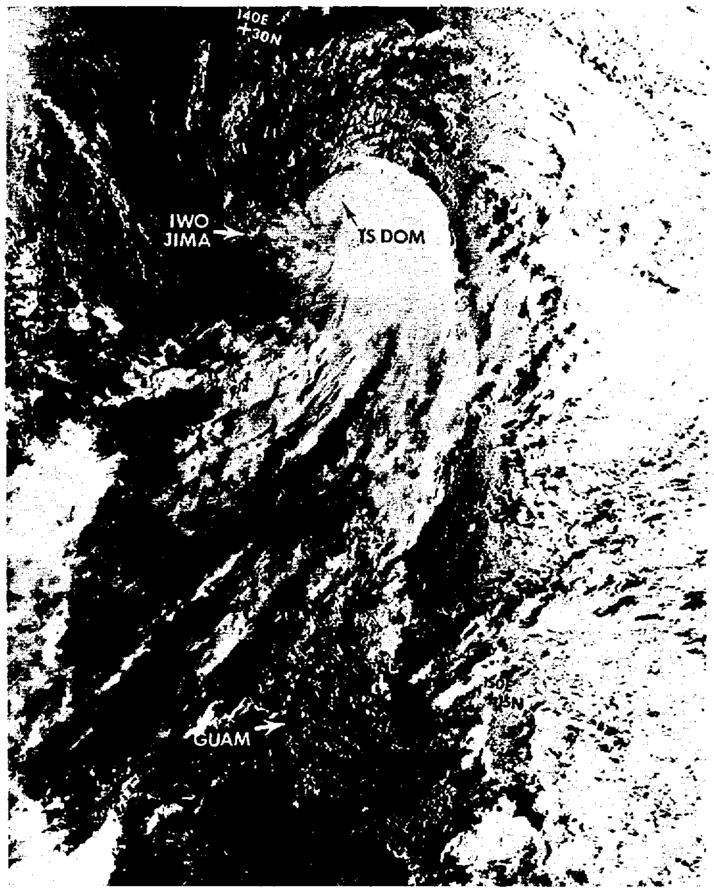
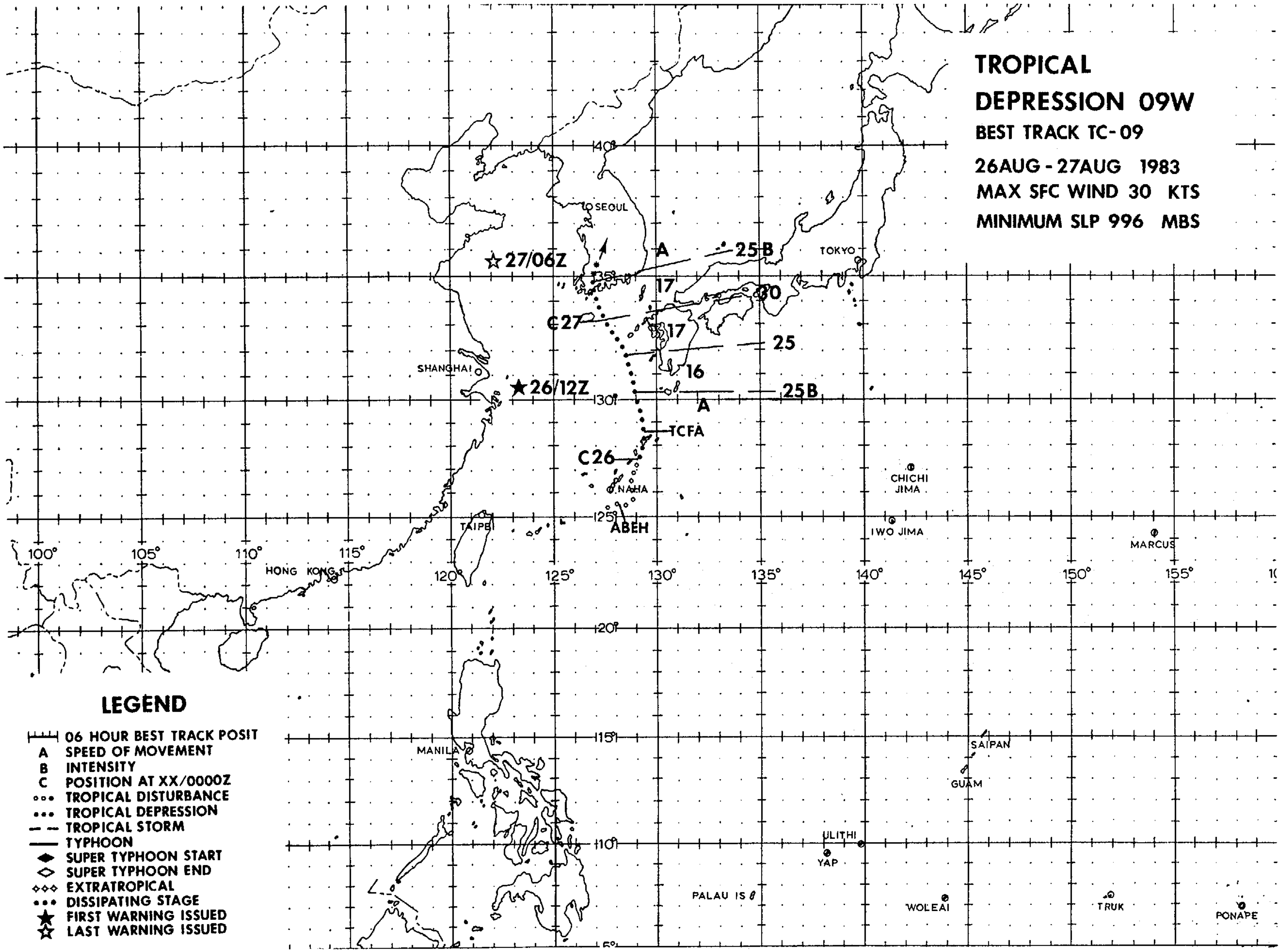


Figure 3-08-5. In a last, but brief, period of reintensification, satellite imagery indicates an upper-level anticyclone forming over Dom's low-level center (242033Z August DMSP visual imagery).


TROPICAL
DEPRESSION 09W
BEST TRACK TC-09
26AUG-27AUG 1983
MAX SFC WIND 30 KTS
MINIMUM SLP 996 MBS
LEGEND
06 HOUR BEST TRACK POSIT
A SPEED OF MOVEMENT
B INTENSITY
C POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
DISSIPATING STAGE
FIRST WARNING ISSUED
LAST WARNING ISSUED
☆27/06Z
★26/12Z
A
25 B
17
30
C27
17
25
16
25B
A
TCFA
C26
ABEH
SEOUL
TOKYO
SHANGHAI
NAHA
TAIPEI
HONG KONG
MANILA
CHICHI JIMA
IWO JIMA
MARCUS
SAIPAN
GUAM
ULITHI
YAP
PALAU IS
WOLEAI
TRUK
PONAPE
40°
35°
30°
25°
20°
15°
10°
5°
100°
105°
110°
115°
120°
125°
130°
135°
140°
145°
150°
155°

Tropical Depression 09W was unusual in that it developed in an area where tropical cyclogenesis is a rare event. It was first detected as a tropical disturbance located 60 nm (111 km) south of Okinawa on the 25th of August. At this time, the monsoon trough was displaced far to the north of its climatological position following the passage of Tropical Storm Dom. Tropical Depression 09W formed to the west of Dom in an area of highly convergent low-level flow.

Tropical Depression 09W was first mentioned in the Significant Tropical Weather Advisory (ABEH PGTW) at 0600Z on the 25th. Upper-level flow in the vicinity of the circulation was highly divergent and Dvorak intensity estimates indicated that maximum sustained winds associated with the circulation were 30 kt (15 m/s). Tropical Depression 09W showed no signs of further development in the next 24 hours of its existence. However, a TCFA was issued at 260400Z because the favorable upper-level conditions indicated a good potential for intensification of the circulation.

Soon after the TCFA was issued, satellite imagery (Figure 3-09-1) revealed an exposed low-level circulation with associated convective activity displaced 300 nm (555 km) to the south. Synoptic data at the time indicated that the central pressure of the depression was below 1000 mb but the area of maximum winds was 100 nm (185 km) from the center. At this point, it was expected that the circulation would become better organized and pose a threat to nearby population centers in Japan and Korea. Accordingly, the first warning on Tropical Depression 09W was issued at 261200Z.

The only aircraft reconnaissance mission flown on this system was conducted at 2330Z on the 26th. Terrain in the area precluded a low-level flight and severaly restricted the collection of peripheral data. However, the height of the 700 mb center supported a maximum surface wind speed of 30 kt (15 m/s). This intensity was in perfect agreement with simultaneous estimates using satellite imagery.

Tropical Depression 09W never developed into a tropical storm and dissipated rapidly after making landfall on the southern coast of Korea. Although the East China Sea was dominated by cloudiness and rain showers during its passage, there were no reports of injury or property damage related to this depression.

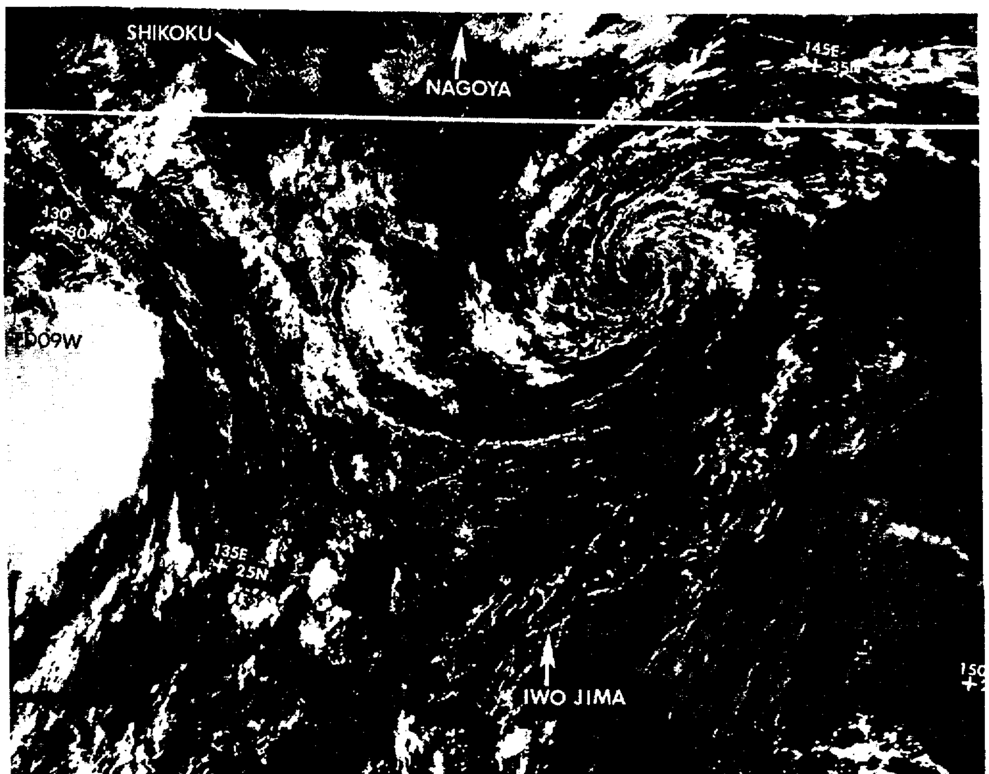
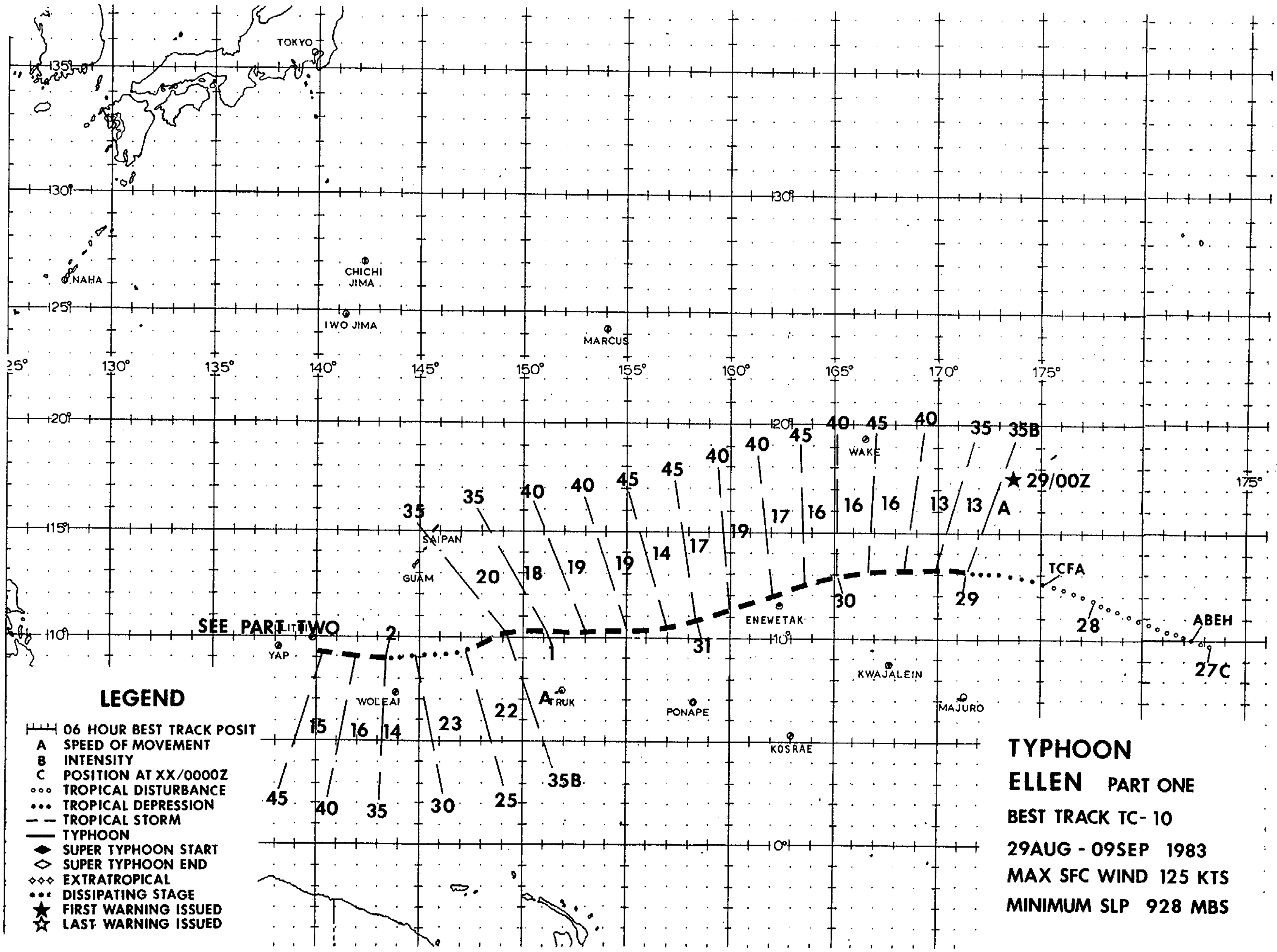
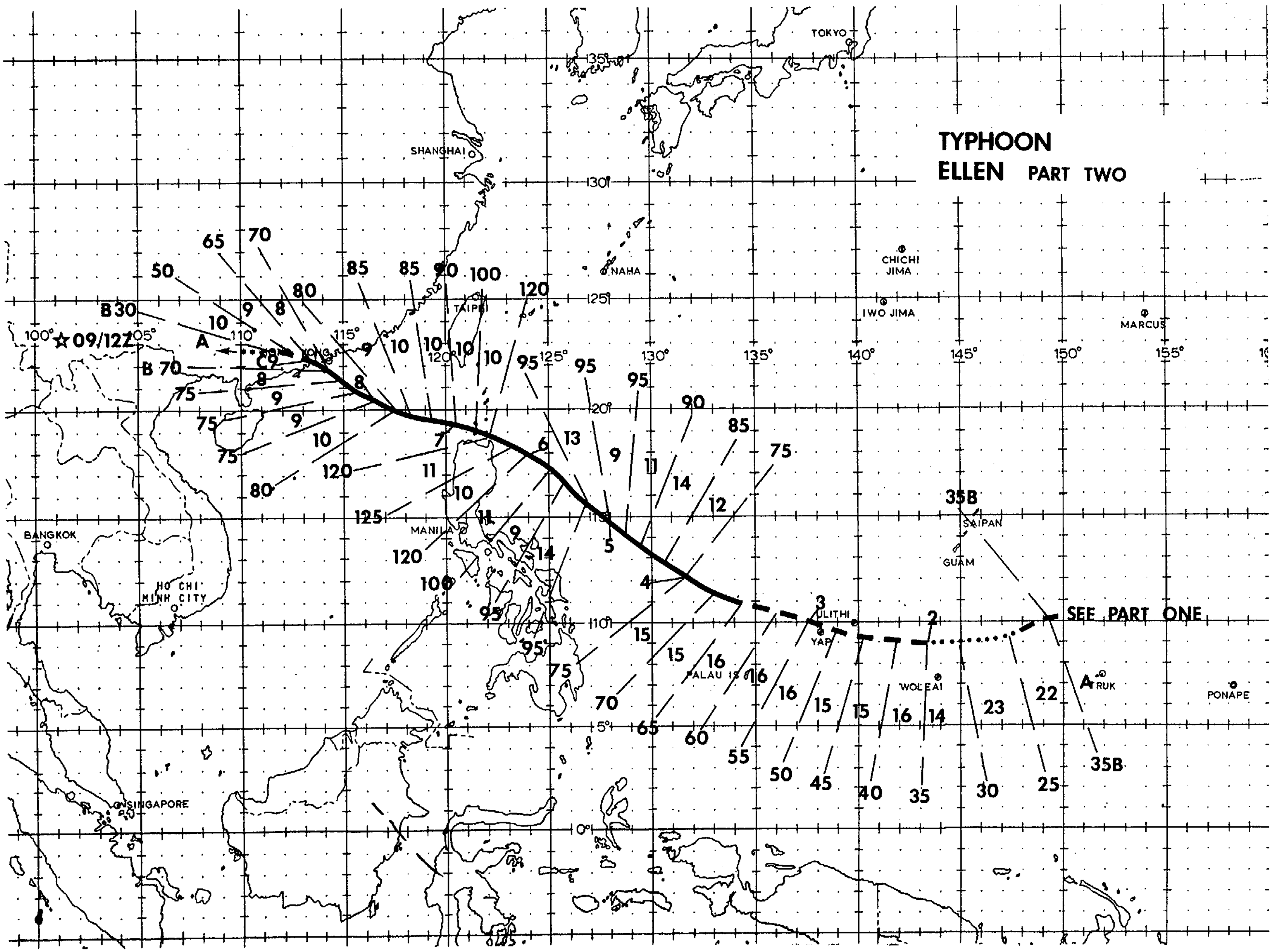


Figure 3-09-1. The exposed low-level circulation of TD 09W (left) and Tropical Storm Dom (right) in its dissipation stage (260546Z August NOAA 7 visual imagery).


TYPHOON
ELLEN PART ONE
BEST TRACK TC- 10
29AUG - 09SEP 1983
MAX SFC WIND 125 KTS
MINIMUM SLP 928 MBS
LEGEND
06 HOUR BEST TRACK POSIT
A SPEED OF MOVEMENT
B INTENSITY
C POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
DISSIPATING STAGE
FIRST WARNING ISSUED
LAST WARNING ISSUED
SEE PART TWO
★ 29/00Z
TCFA
ABEH
TOKYO
NAHA
CHICHI JIMA
IWO JIMA
MARCUS
SAIPAN
GUAM
YAP
WOLEAI
TRUK
PONAPE
KOSRAE
ENEWETAK
WAKE
KWAJALEIN
MAJURO


TYPHOON
ELLEN PART TWO
SEE PART ONE
09/12Z
TOKYO
SHANGHAI
NAHA
CHICHI JIMA
IWO JIMA
MARCUS
TAIPEI
MANILA
BANGKOK
HO CHI MINH CITY
SAIPAN
GUAM
ULITHI
YAP
PALAU IS
WOLEAI
TRUK
PONAPE
SINGAPORE

Typhoon Ellen first became apparent on satellite imagery as a tropical disturbance located near 10N 170W on the 26th of August. The disturbance was located in a data-sparse area, making it difficult to estimate its degree of organization or intensity. Satellite intensity estimates using the Dvorak method indicated maximum sustained winds of 30 kt (15 m/s). These estimates were based primarily on the presence of upper-level banding features. Because of its impressive appearance on satellite imagery, the disturbance was mentioned in the Significant Tropical Weather Advisory (ABEH PGTW) on the 27th. At this time, the disturbance was not located in the JTWC area of responsibility (AOR) but it was moving westward and it was becoming a matter of increasing concern to interests in the eastern portion of the JTWC AOR.

The disturbance crossed the dateline and entered the JTWC AOR on the 28th. A TCFA was issued at 281100Z as the system, now associated with a weak upper-level anticyclone, continued moving westward. Satellite imagery indicated that the disturbance was intensifying with maximum sustained winds of 35 kt (18 m/s). This prompted the issuance of the first warning on Ellen at 290000Z which projected continued west-northwestward movement and intensification.

During the next five days, Ellen's intensity fluctuated between 25 and 45 kt (13-23 m/s). Further development during this period was inhibited by the lack of low-level westerly inflow and the restriction of upper-level outflow channels to the north by a large upper-level anticyclone centered south of Japan. This large upper-level anticyclone was a manifestation of an intense cell of high pressure which extended throughout the troposphere and had a tremendous impact on Ellen. In addition to interferring with Ellen's outflow at upper-levels, it prevented continued west-northwestward movement and caused Ellen to assume a southwestward track around its southern periphery at speeds of 13 to 23 kt (7-12 m/s). This high speed of movement, combined with outflow restrictions, caused Ellen to weaken to tropical depression intensity briefly on the 1st of September.

After reaching a minimum intensity of 25 kt (13 m/s) at 011200Z, Ellen began to strengthen, reaching typhoon intensity two days later at 031200Z. Upper-level flow patterns during this period were very favorable for the development of outflow channels. A TUTT cell over the South China Sea (Figure 3-10-1) was instrumental in providing the proper environment for the establishment of outflow to the north. Coincident with Ellen's intensification was a change in track from west-southwestward to west-northwestward. This marked Ellen's transit beyond the southernmost point of the massive high previously discussed.

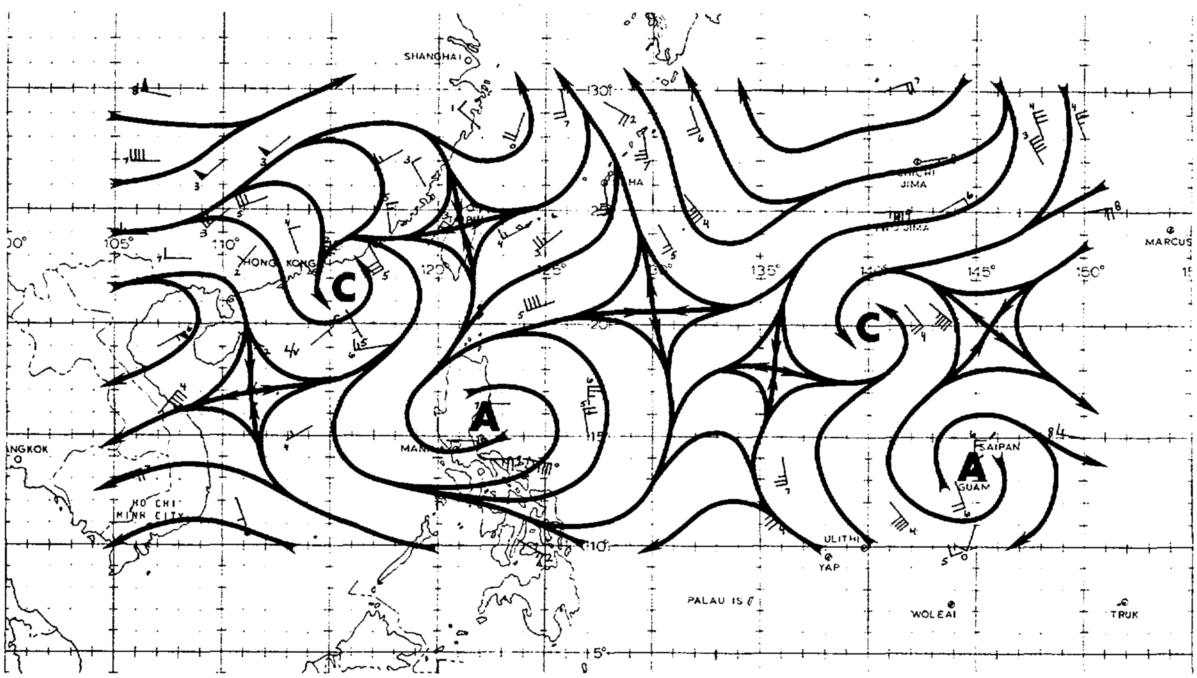


Figure 3-10-1. Favorable upper-level conditions led to Ellen's reintensification after weakening to a tropical depression on 1 September (021200Z September 200 mb analysis).

By 051200Z, Ellen was located 200 nm (370 km) east of Luzon with maximum sustained winds of 95 kt (49 m/s). An objective technique for forecasting the onset of explosive deepening (Dunnavan, 1981) indicated that Ellen would deepen rapidly over the next 34 hours. The reliability of this technique was verified when Ellen's central pressure dropped 28 mb to 928 mb over the next 12 hours. Ellen reached maximum intensity of 125 kt (64 m/s) shortly thereafter, at 060600Z (Figure 3-10-2).

This peak in intensity was short-lived due to interaction between the southern part of Ellen's circulation and Luzon. Ellen weakened continuously from this point on as it moved through the Luzon Straits and headed for southern China.

Fix information on Ellen was exceptionally good. In addition to normal aircraft reconnaissance, three fixes a day from the 3rd to the 7th were provided by an aircraft flying special aircraft stress test penetrations. This aircraft and crew were from the 53rd Weather Reconnaissance Squadron at Keesler AFB, Mississippi. In addition to supplemental aircraft reconnaissance flights, radar coverage of Ellen by land stations was extensive. Radar reports from Aparri, P.I. (WMO 98231), Kaohsiung, China (WMO 46744) and the Royal Observatory, Hong Kong (WMO 45005) provided nearly continuous coverage from the Luzon Straits to landfall near Macao.

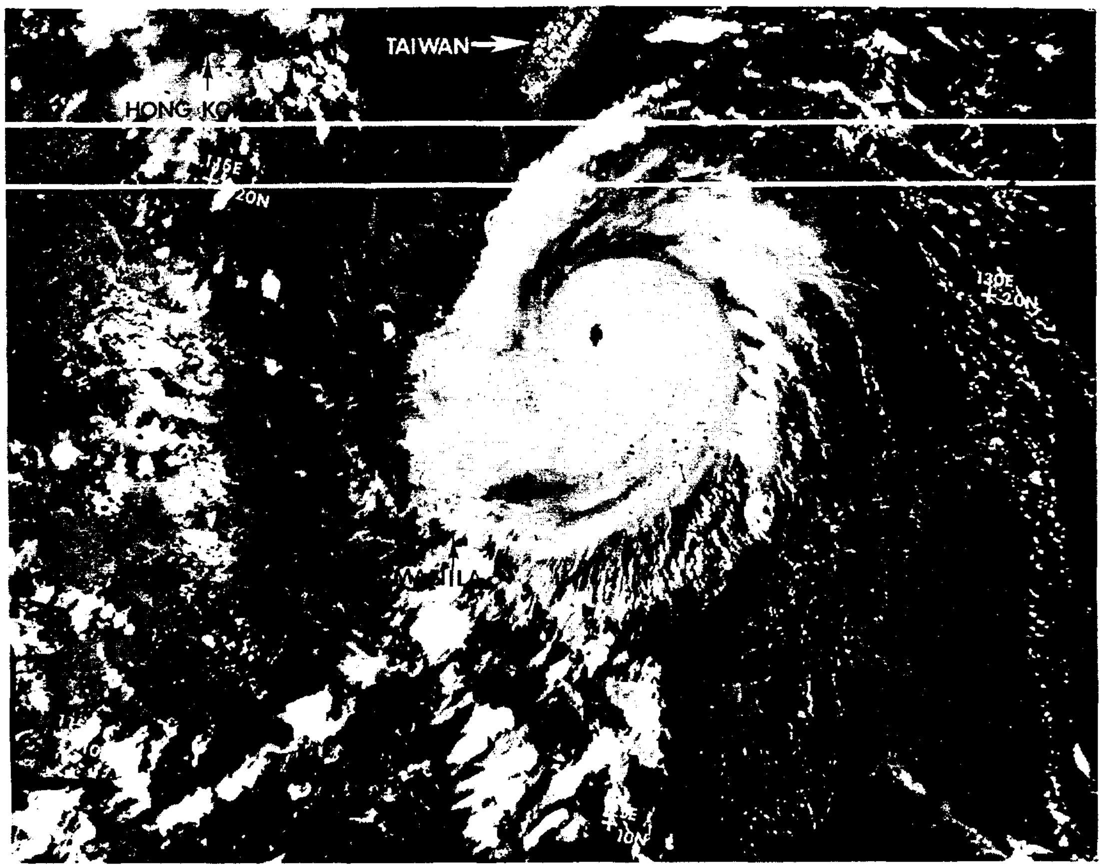
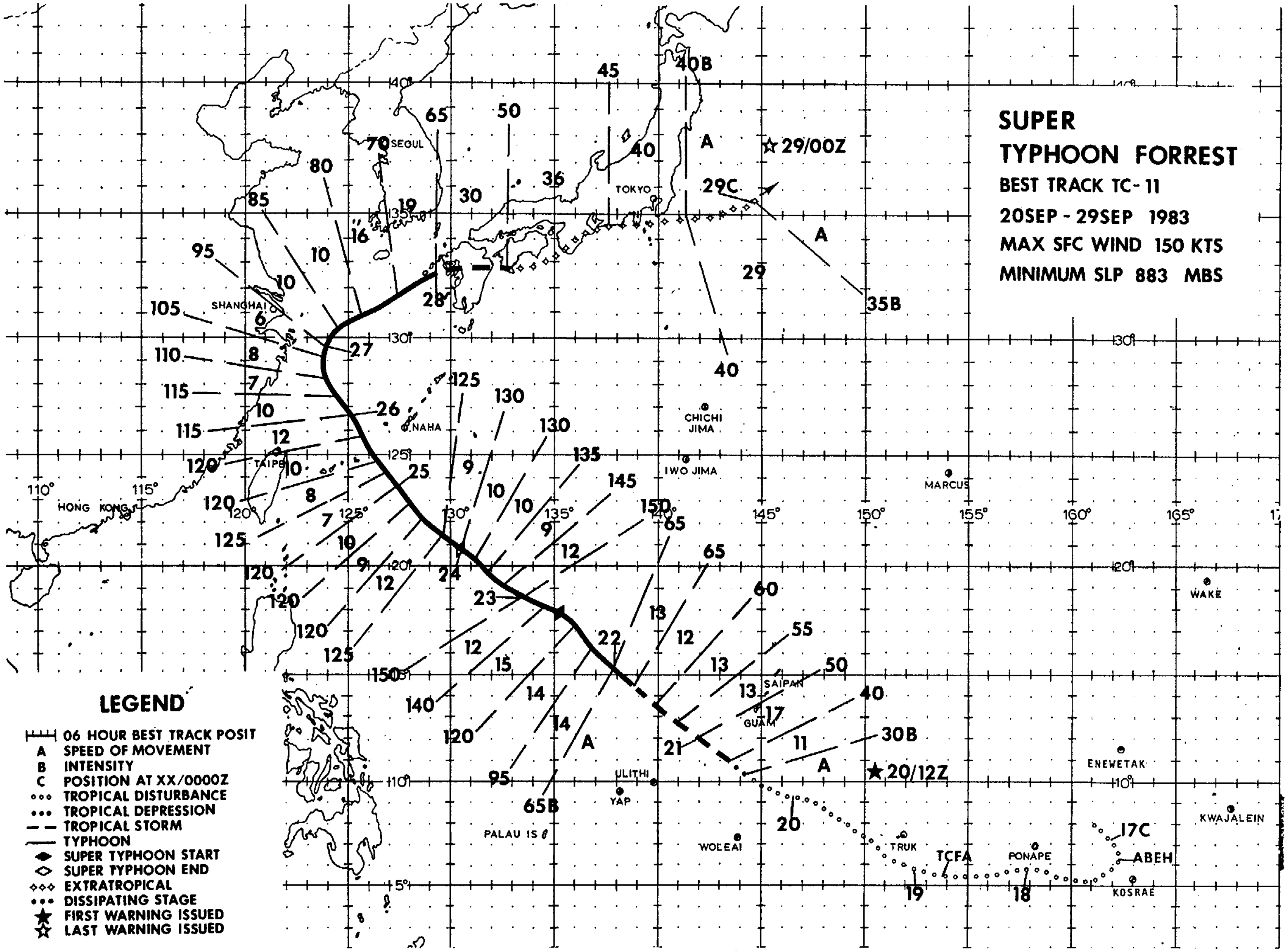


Figure 3-10-2. Typhoon Ellen at maximum intensity (060653Z September NOAA 7 visual imagery).

Ellen made landfall just south of Macao at 0000Z on the 9th of September. Maximum sustained winds at landfall were 65 kt (33 m/s) with gusts to 80 kt (41 m/s). Higher winds due to channelling effects were recorded at the Royal Observatory, Hong Kong, with the highest reported at 90 kt (46 m/s) gusting to 140 kt (72 m/s).

Damages in Hong Kong were extensive. Preliminary reports indicated that six people were killed and 277 were injured, with 120 requiring hospitalization. More than 1,600 people sought emergency shelter, mostly residents of makeshift hillside dwellings swept away by high winds, flooding, and landslides. Damages to shipping were also extensive. The Hong Kong Marine Department reported that 22 ships ran aground during Ellen's passage.

After moving inland, Ellen dissipated rapidly, becoming a 30 kt (15 m/s) tropical depression within 12 hours after making landfall.


SUPER
TYPHOON FORREST
BEST TRACK TC-11
20SEP - 29SEP 1983
MAX SFC WIND 150 KTS
MINIMUM SLP 883 MBS
LEGEND
06 HOUR BEST TRACK POSIT
A SPEED OF MOVEMENT
B INTENSITY
C POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
DISSIPATING STAGE
FIRST WARNING ISSUED
LAST WARNING ISSUED
29/00Z
20/12Z
35B
40B
30B
65B
29C
17C
TCFA
ABEH
SEOUL
TOKYO
SHANGHAI
HONG KONG
TAIPEI
NAHA
CHICHI JIMA
IWO JIMA
MARCUS
WAKE
SAIPAN
GUAM
ULITHI
YAP
PALAU IS
WOLEAI
TRUK
PONAPE
ENEWETAK
KWAJALEIN
KOSRAE

Forrest was the most intense of all of the tropical cyclones of 1983. After taking a long time to reach tropical storm intensity, it intensified from a tropical storm to a super typhoon in 30 hours and reached a maximum intensity of 150 kt (77 m/s) (Figure 3-11-1).

Forrest developed from a tropical disturbance which originated in a broad area of convective activity located 300 nm (556 km) to the east of Ponape (WMO 91348). This disturbance was first discussed in the Significant Tropical Weather Advisory (ABEH PGTW) on the 17th of September. At this time, the disturbance had a great deal of associated convection but was not well organized. However, a reconnaissance aircraft was dispatched to the area when 24 hour pressure drops of 3 mb at nearby stations were recorded. The aircraft mission confirmed the lack of organization in the system and was not able to close off a circulation. This mission was the first of four aircraft reconnaissance flights into Forrest during the period 17-20 September. All four were unable to close off a surface circulation. However, the fourth aircraft did succeed in closing off a circulation at the 700 mb level, thereby lending credence to the theory that Forrest originated from a mid-level circulation which developed downward.

Even though aircraft reconnaissance indicated the lack of a surface circulation, a TCFA was issued for the disturbance at 181801Z when the convection associated with it began to intensify and expand. The alert was reissued 24 hours later, after the second aircraft reconnaissance mission failed to close off a surface circulation.

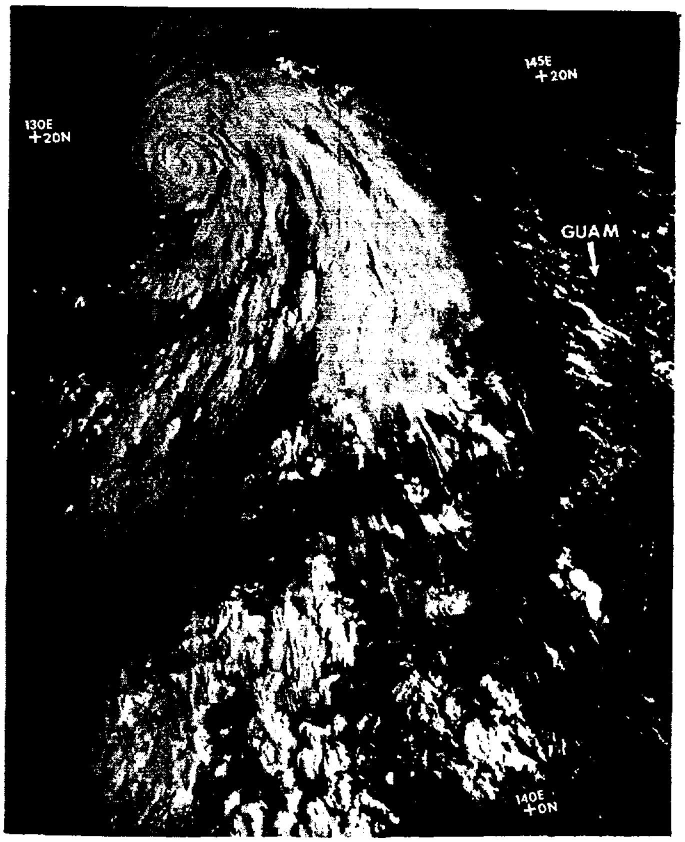


Figure 3-11-1. Super Typhoon Forrest at maximum intensity with 150 kt (77 m/s) winds and MSLP of 883 mb (222223Z NOAA 8 visual imagery).

The third and fourth aircraft reconnaissance missions were flown on the morning and afternoon of 20 September. Although both flights confirmed the absence of a surface circulation during the day, the first warning was issued later that evening when satellite imagery indicated the formation of a central dense overcast and good outflow to all quadrants. At this time, Forrest was located about 180 nm (330 km) south of Guam. The forecast called for continued gradual intensification and slow northwestward movement. Although this forecast track verified well, the intensity projections were far short of the mark. Reconnaissance aircraft flying a mission on the following morning encountered 50 to 60 kt (21-26 m/s) winds in Forrest's well-defined circulation. Continued intensification after this occurred rapidly. Forrest was upgraded to a typhoon at 211800Z when satellite imagery indicated a developing eye. Aircraft dropsonde data at 212340Z indicated that Forrest's central pressure had dropped to 975 mb. About 11 hours later, at 221057Z, a sea-level pressure of 883 mb was recorded. This represented a drop of 92 mb in a little under 24 hours. This is graphically displayed in a plot of Forrest's central sea-level pressure over time (Figure 3-11-2). Note the rapid drop in pressure on the 22nd.

Fortunately, Forrest's rapid intensification occurred after the system had moved well clear of Guam. Even though Forrest was relatively weak when it passed Guam, the island was subjected to winds gusting in excess of 30 kt (15 m/s) and heavy rains. About 2 inches (5 cm) of badly needed rain fell, causing minor flooding but no serious damage.

As Forrest moved northwestward and intensified, it became apparent that a recurvature scenario was developing. A break in the subtropical ridge between Taiwan and Okinawa was clearly and consistently indicated in the NOGAPS numerical prognoses. Forrest was therefore forecast to continue moving northwestward and recurve in the vicinity of this weakness. This forecast verified well except for the precise time and location of the point of recurvature. Forrest continued moving northwestward longer than expected.

Prior to recurvature, Forrest passed 107 nm (198 km) southwest of Okinawa, subjecting the island to high winds and heavy rain. Maximum sustained winds recorded at Kadena Air Base were 50 kt (26 m/s) with gusts to 74 kt (38 m/s). Rainfall totalling 11.65 inches (30 cm) resulted in flooding which caused minor damage to the installation. Other damages due to high winds were limited to minor personnel injuries and the loss of some antennas. Preliminary reports from Japanese authorities indicated that the civilian population of Okinawa weathered the storm equally well.

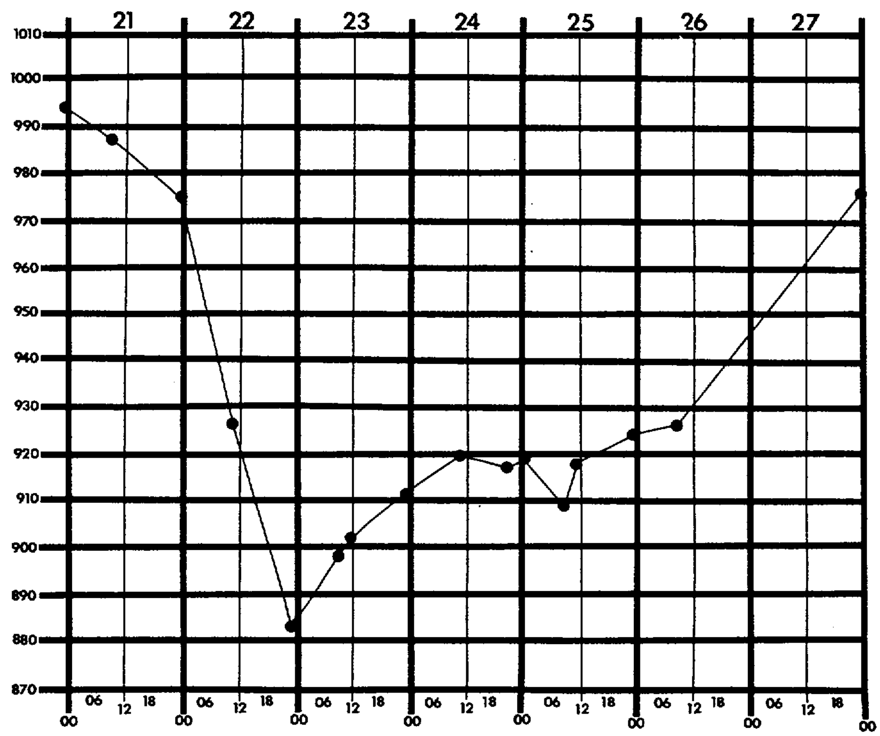


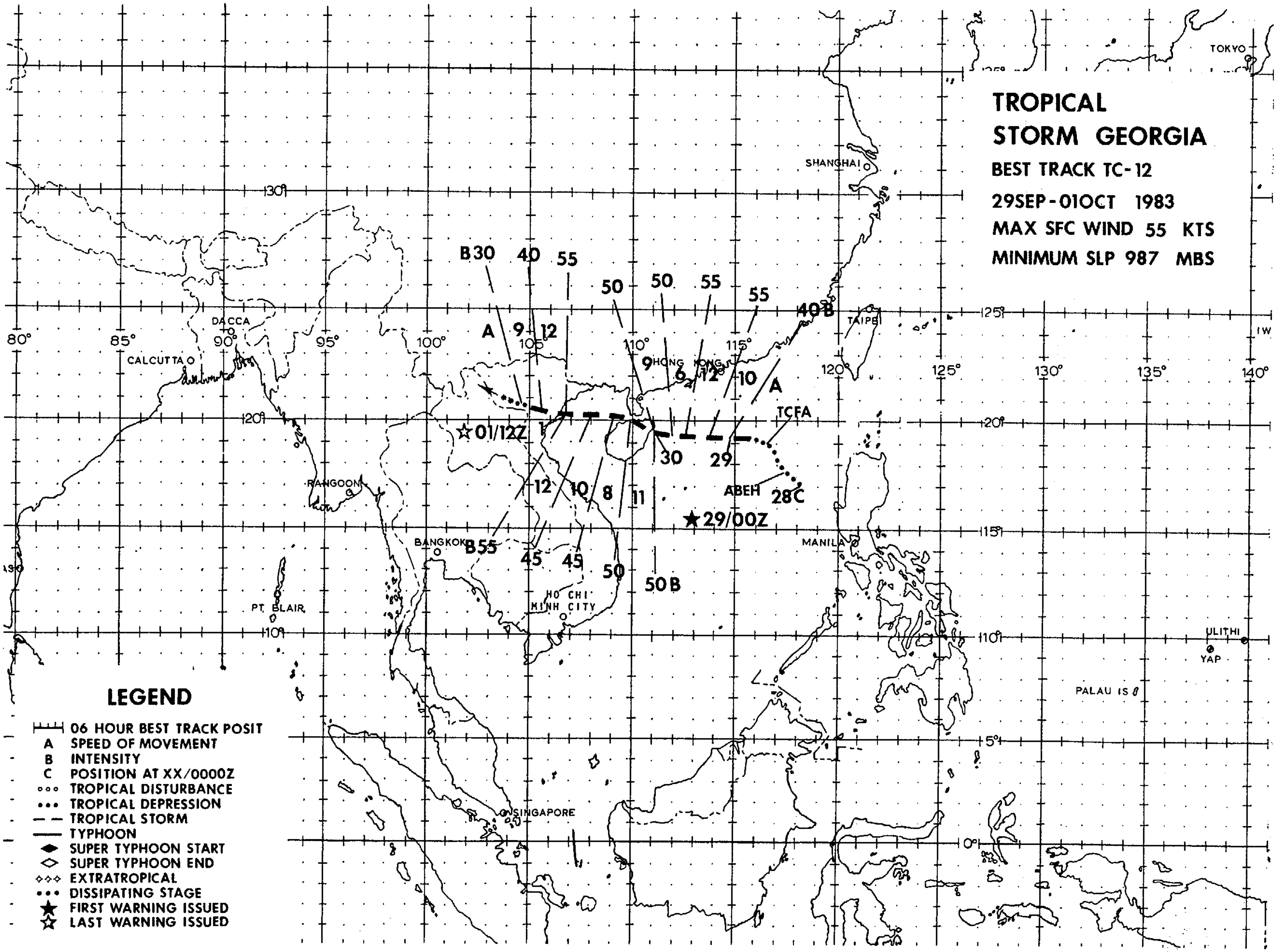
Figure 3-11-2. Intensity trends for Forrest as indicated by a plot of MSLP versus time.

Residents of Inza Island, northwest of Okinawa, were not so fortunate. A tornado, spawned during the passage of Forrest, cleared a swath 300 ft (91 m) wide across the island, destroying seven homes and injuring 26 people, some seriously. There were also reports of tornadoes over Okinawa, however, none of these touched down.

While moving past Okinawa, Forrest began to interact with a frontal system moving off the Asian continent. Within 48 hours of the onset of this interaction, satellite imagery indicated that Forrest had lost its deep convection and had begun to take on extratropical characteristics. Shortly thereafter, Forrest recurved to the east-northeast and accelerated rapidly.

Forrest weakened dramatically while undergoing extratropical transition. This was fortunate since its track during this period carried it into heavily populated areas of southern Japan at speeds up to 40 kt (74 km/hr). While crossing the island of Kyushu, Forrest passed approximately 25 nm (45 km) south of Sasebo. Inport at Sasebo were five U.S. Navy ships and several ships of the Japanese Maritime Self Defense Force. This harbor had previously been evaluated as a safe typhoon haven due to the sheltering effects of the topography in the area. This evaluation was proven correct when none of the ships in the harbor suffered damages during the passage of Forrest. Other areas in southern Japan suffered extensively from high winds and heavy rains. Initial reports indicated 21 dead, 86 injured and 17 missing. Heavy rains, up to 19 inches (48 cm) in some areas, caused numerous landslides and widespread flooding resulting in damages to 46,000 homes, some of which were total losses. The storm also stranded 28,000 travelers due to the disruption of domestic flights and rail service.

Forrest completed extratropical transition on the 28th at 0600Z while located near the southern tip of Shikoku. From this point on, Forrest continued to weaken and move rapidly toward the east-northeast as an extratropical system. Forrest was continued in warning status for an additional 18 hours until 190000Z when the final warning was issued. At this point, Forrest had cleared Japan and was moving eastward as an extratropical low with maximum sustained winds of 35 kt (18 m/s).


TROPICAL STORM GEORGIA
BEST TRACK TC-12
29SEP-01OCT 1983
MAX SFC WIND 55 KTS
MINIMUM SLP 987 MBS
LEGEND
06 HOUR BEST TRACK POSIT
A SPEED OF MOVEMENT
B INTENSITY
C POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
DISSIPATING STAGE
FIRST WARNING ISSUED
LAST WARNING ISSUED
TOKYO
SHANGHAI
TAIPEI
HONG KONG
MANILA
DACCA
CALCUTTA
RANGOON
BANGKOK
HO CHI MINH CITY
PT. BLAIR
SINGAPORE
ULITHI
YAP
PALAU IS
TCFA
ABEH
28C
29
30
★29/00Z
☆01/12Z
B30
40
55
50
40B
B55
45
50B
80°
85°
90°
95°
100°
105°
110°
115°
120°
125°
130°
135°
140°
30°
25°
20°
15°
10°
5°
0°

The disturbance that was to become Tropical Storm Georgia originated in a broad area of convective activity located to the west of Luzon in the South China Sea. The southwesterly monsoon was well established in this area at the time, creating an area of high cyclonic vorticity at the intersection of this flow and the easterly tradewind flow at the southern periphery of the subtropical ridge. Georgia was the first of five tropical cyclones to achieve tropical storm intensity in this active monsoon trough.

The weak surface circulation which became Georgia first came to the attention of JTWC forecasters when a upper-level anticyclone formed over it on the 28th of September. This development was accompanied by a rapid increase in the organization and intensity of the circulation. A TCFA was issued at 281459Z when the increase in organization of the system, apparent from satellite imagery, was confirmed by synoptic reports indicating that the MSLP had dropped below 1003 mb.

The circulation continued to intensify rapidly through the night. When a reconnaissance aircraft investigated the area on the following morning, it encountered a tropical storm with maximum sustained winds of 40 kt (21 m/s) and an MSLP of 996 mb. The first warning on Tropical Storm Georgia was issued on receipt of the data from the aircraft at 290000Z.

Georgia tracked westward from this point on with only a slight deviation northward in the vicinity of Hai-Nan island due to topographical effects. This track was accurately predicted by most objective techniques available to JTWC forecasters. A strong subtropical ridge to the north of Georgia was expected to build westward during the period and keep the storm on a westward track. Daily height change analyses at 500 and 700 mb indicated that the ridge was indeed building as expected, causing Georgia to continue moving westward.

Georgia intensified to a maximum intensity of 55 kt (28 m/s) 12 hours prior to landfall on Hai-Nan island (Figure 3-12-1). The passage over Hai-Nan weakened Georgia slightly causing it to enter the Gulf of Tonkin with an intensity of 45 kt (23 m/s). However, Georgia reintensified while crossing the Gulf and made landfall on the coast of Vietnam with an intensity of 55 kt (28 m/s).

The timing and location of Georgia's arrival in Vietnam amplified the damages wrought by the storm. Georgia struck a low-lying agricultural area, Bac Bo, when the tide was rising and the rice crop was in the earing stage. Preliminary estimates of losses included 26 dead, 7,000 buildings damaged or destroyed and the loss of 247,000 acres (100,000 hectares) of rice. In surrounding areas, the arrival of Georgia proved beneficial. The rainfall associated with the storm, 13 to 14 inches (33 to 36 cm) in Thai Binh and Ha Nam provinces, signalled the end of an extensive drought. Rainfall associated with Georgia provided sufficient water to allow the cultivation of additional acreage for rice and filled lakes and reservoirs which could be used for irrigation of the winter and spring rice crops.

After making landfall, Georgia continued westward and dissipated rapidly in the mountains near the Laos/Vietnam border.

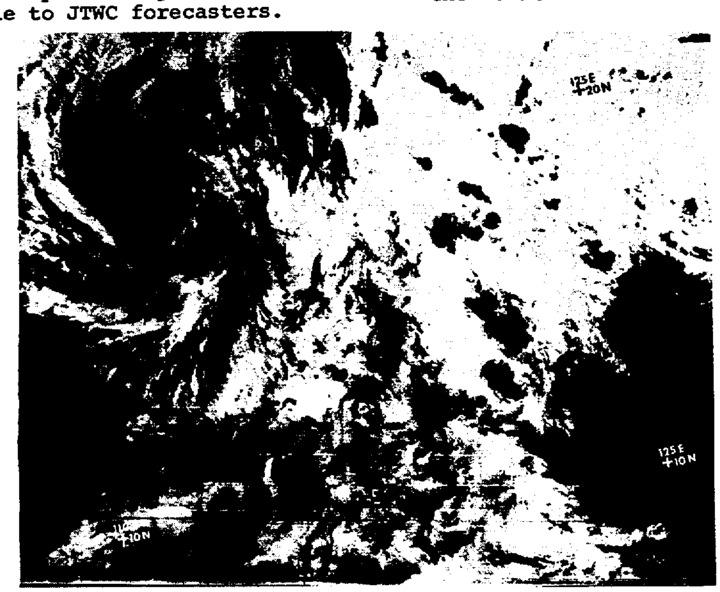
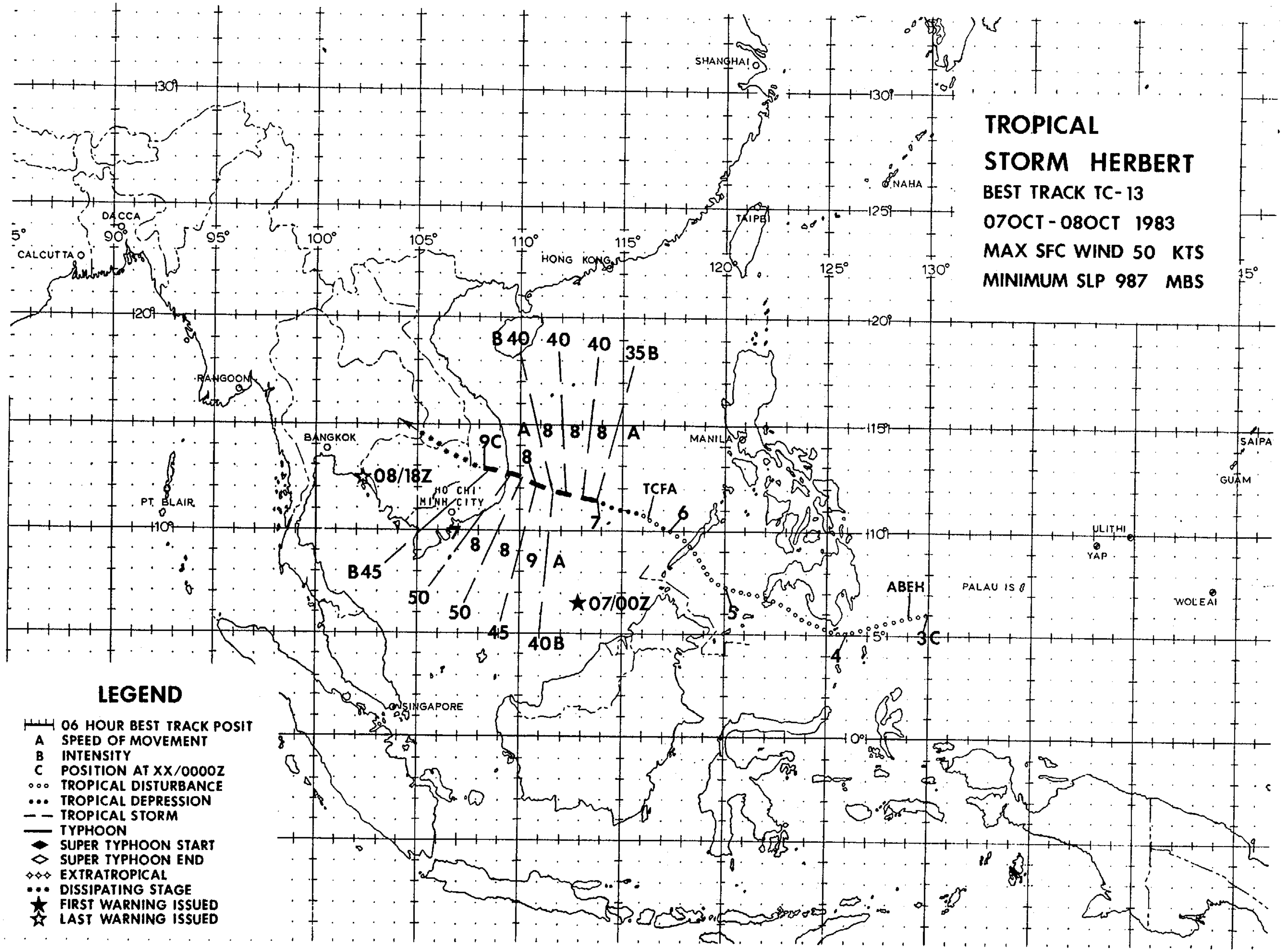


Figure 3-12-1. Tropical Storm Georgia at maximum intensity in the South China Sea (upper left). The disturbance in the lower right was the subject of a TCFA but did not develop (291026Z September DMSP infrared imagery).


TROPICAL
STORM HERBERT
BEST TRACK TC-13
07OCT-08OCT 1983
MAX SFC WIND 50 KTS
MINIMUM SLP 987 MBS
LEGEND
06 HOUR BEST TRACK POSIT
A SPEED OF MOVEMENT
B INTENSITY
C POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
DISSIPATING STAGE
FIRST WARNING ISSUED
LAST WARNING ISSUED
SHANGHAI
NAHA
TAIPEI
DACCA
CALCUTTA
HONG KONG
RANGOON
BANGKOK
MANILA
HO CHI MINH CITY
PT. BLAIR
SINGAPORE
SAIPAN
GUAM
ULITHI
YAP
PALAU IS
WOLEAI
ABEH
TCFA
08/18Z
07/00Z

Tropical Storm Herbert formed from a tropical disturbance which was first observed on 3 October as an area of unorganized convective activity located 250 nm (463 km) east of Mindanao. At this time, a weak surface circulation was apparent in the synoptic wind field associated with this convection. Maximum sustained surface winds were 15 kt (8 m/s) and the MSLP was 1010 mb. In spite of the apparent weakness of this disturbance, it was closely monitored by JTWC because a TUTT cell located to the north of the disturbance provided a favorable environment for the establishment of outflow channels.

Convective activity associated with this disturbance remained high over the next three days as the circulation moved westward over the Philippines but there was no increase in the intensity of the system until it emerged in the South China Sea. On the 6th of October, the disturbance entered an area of strong southwesterly monsoon flow and began to intensify. Satellite imagery at the time indicated the formation of convective banding in spite of the fact that upper-level flow was northeasterly and no longer highly divergent. A TCFA was issued at 060700Z on the basis of the increase in organization apparent from satellite imagery. Figure 3-13-1 shows Herbert at the time the alert was issued.

The system continued to intensify over the next 18 hours. At 070019Z, a reconnaissance aircraft was able to locate a well-defined surface circulation with 35 kt (18 m/s) winds, prompting the first warning by JTWC valid for 070000Z. Forecasts for Herbert anticipated continued west-northwestward movement and minimal intensification prior to landfall on the coast of Vietnam. This scenario proved correct as Herbert achieved a maximum intensity of 50 kt (26 m/s) six hours prior to landfall north of Nha Trang, Vietnam at 081200Z. Herbert dissipated rapidly over the mountainous terrain of central Vietnam but persisted as an area of enhanced convection and reduced surface pressures for several days as it moved westward over Indochina.

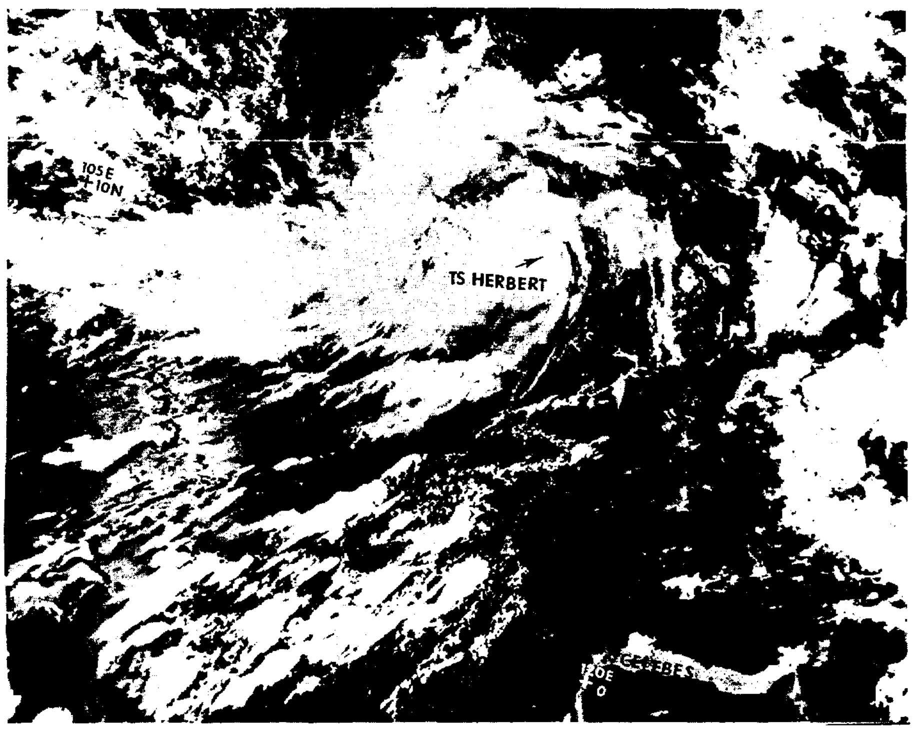
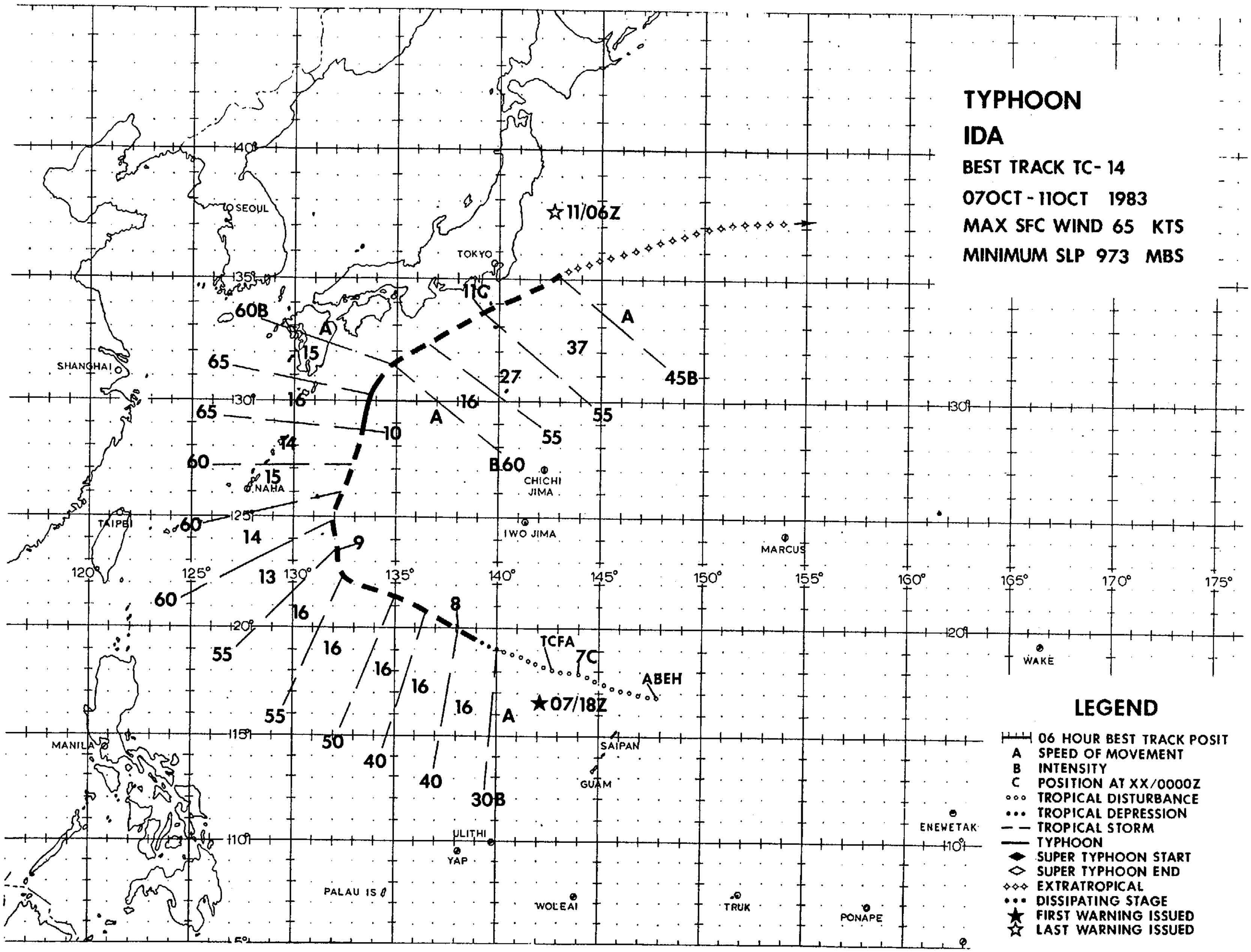


Figure 3-13-1. Herbert as a tropical depression in the South China Sea (060730Z NOAA 7 visual imagery).



TYPHOON
IDA
BEST TRACK TC-14
07OCT - 11OCT 1983
MAX SFC WIND 65 KTS
MINIMUM SLP 973 MBS
LEGEND
06 HOUR BEST TRACK POSIT
A SPEED OF MOVEMENT
B INTENSITY
C POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
DISSIPATING STAGE
FIRST WARNING ISSUED
LAST WARNING ISSUED
11/06Z
07/18Z
TCFA
ABEH
SEOUL
TOKYO
SHANGHAI
TAIPEI
NAHA
CHICHI JIMA
IWO JIMA
MARCUS
WAKE
SAIPAN
GUAM
MANILA
ULITHI
YAP
PALAU IS
WOLEAI
TRUK
PONAPE
ENEWETAK

The origins of Ida can be traced to an inverted trough which was first detected near Saipan (WMO 91232) using synoptic data on 6 October. Although this is the earliest point at which a reliable track can be established, there appears to be a linkage between the inverted trough and a convective cloud mass which developed approximately one week earlier in the center of a TUTT cell.

After Super Typhoon Forrest underwent extratropical transition in the vicinity of Japan, a TUTT cell located about 270 nm (500 km) west of Johnston Island (WM 91275) appeared to expand and intensify. As the frontal system, containing the extratropical remains of Forrest, passed to the north, the TUTT cell moved westward at about 10 kt (19 km/hr) and intensified. By 3 October, a mass of convective cloudiness had developed in the center of the TUTT cell near Wake Island (WMO 91245).

Over the next three days, the disturbance moved generally westward but fluctuated radically in position and intensity to the extent that it could not be reliably tracked as the same disturbance. During this period, the passage of another frontal system to the north and the formation of another TUTT cell to the southeast contributed to the confused state of the atmosphere in the area.

The inverted trough which was located near Saipan at 060000Z rapidly developed and became a closed circulation with 20 kt (10 m/s) winds by 061200Z. Signs of continued development, pressure falls in the area and increasing winds at nearby stations, led to the issuance of a TCFA at 070745Z.

The first warning on Ida as a tropical depression was issued at 071800Z when it became evident from satellite imagery that a central convective feature was forming. Upgrade to tropical storm status followed on the subsequent warning after reconnaissance aircraft revealed that maximum sustained winds associated with Ida had risen to 40 kt (21 m/s) and MSLP had dropped to 1000 mb.

Initial forecasts called for continued northwestward movement and intensification prior to recurvature south of Japan. Ida moved northwestward as expected and intensified, reaching a maximum intensity of 65 kt (33 m/s) on the 10th after turning north-northeastward (Figure 3-14-1). Shortly after reaching maximum intensity, Ida began to interact with a frontal system to the north. This resulted in a weakening and acceleration to the northeast as Ida underwent extratropical transition. Ida's track south of Japan was well documented by timely reports from Japanese radar stations which proved invaluable in positioning the rapidly moving system.

Although Ida passed close to the island of Honshu, approximately 80 nm (148 km) southeast of Tokyo, there were no reports of storm related damage in Japan. The small radius of high winds associated with Ida and the fact that it was weakening as it passed Japan were fortunate circumstances.

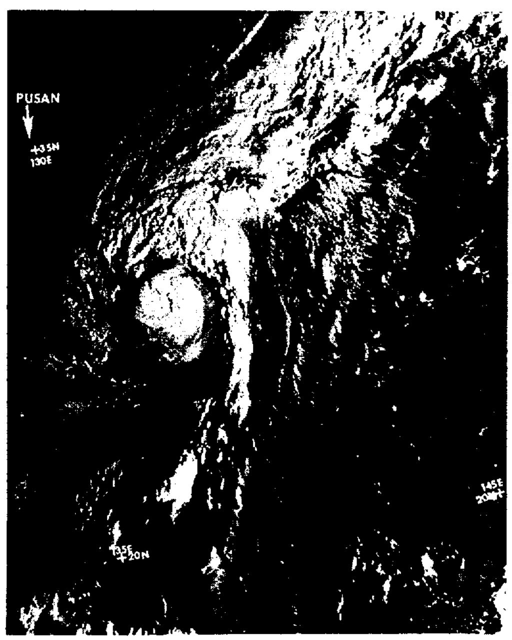
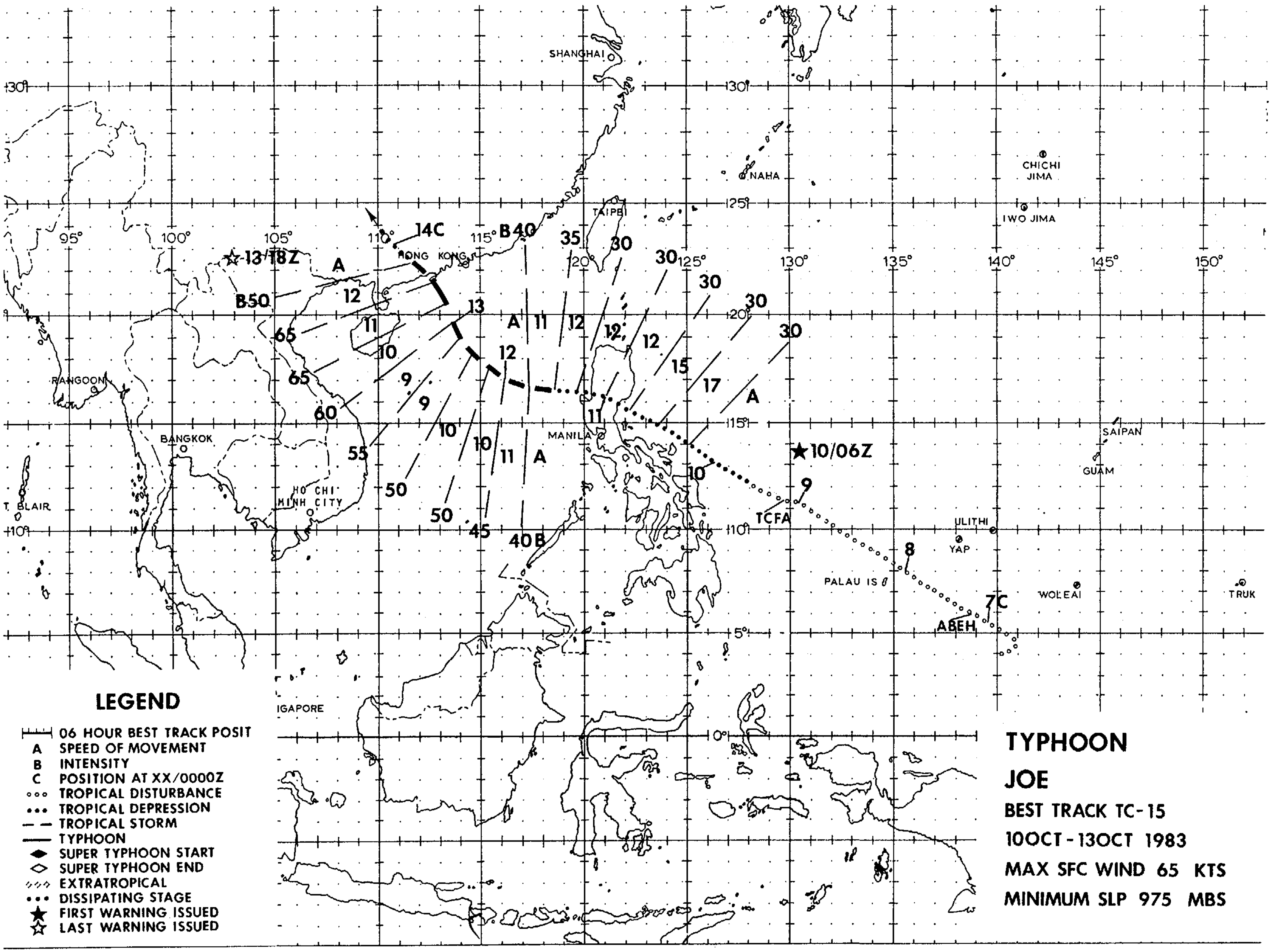


Figure 3-14-1. Ida near maximum intensity. Interaction with the frontal system to the north led to the extratropical transition and rapid acceleration of the system (092258Z October NOAA 8 visual imagery).


SHANGHAI
NAHA
CHICHI JIMA
IWO JIMA
TAIPEI
HONG KONG
RANGOON
BANGKOK
HO CHI MINH CITY
MANILA
SAIPAN
GUAM
ULITHI
YAP
PALAU IS
WOLEAI
TRUK
T. BLAIR
IGAPORE
☆13/18Z
★10/06Z
14C
B40
B50
40B
TCFA
ABEH
7C
LEGEND
06 HOUR BEST TRACK POSIT
A SPEED OF MOVEMENT
B INTENSITY
C POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
DISSIPATING STAGE
FIRST WARNING ISSUED
LAST WARNING ISSUED
TYPHOON
JOE
BEST TRACK TC-15
10OCT-13OCT 1983
MAX SFC WIND 65 KTS
MINIMUM SLP 975 MBS

During the month of October, tropical cyclone activity in the western Pacific was concentrated in the South China Sea. Six tropical cyclones formed between 29 September and 26 October in the western Pacific. Five of the six, formed as tropical depressions in the Philippine Sea and crossed the Philippines prior to intensifying in the South China Sea. All five moved westward without recurving. Typhoon Joe (15W) was the most intense of these and the only one of the five to achieve typhoon intensity.

Joe's origins can be traced back to 6 October when it was detected as a tropical disturbance located well to the south of Guam It was first discussed on the Significant Tropical Weather Advisor (ABEH PGTW) on the following day and was monitored by JTWC as it moved westward. At 090000Z October, synoptic data indicated that the MSLP in the disturbance was near 1006 mb and that a closed surface circulation was developing. Winds of up to 25 kt (13 m/s) were estimated from satellite analysis as convective cloudiness and organization increased. A TCFA was issued at this time in anticipation of continued intensification. The area covered by the alert was later shifted southward when satellite imagery indicated that the predominant circulation center was forming well to the south of the areas that had previously been fixed. Satellite fixes were now scattered over an area that was too large to be accounted for by either storm movement or nominal position error. The presence of multiple circulation centers was considered as a possible explanation for this excessive fix scatter.

An aircraft investigation of the area, completed at 100204Z, revealed a closed circulation center with a central pressure of 1003 mb and 30 kt (15 m/s) winds. The mission ARWO (Aerial Reconnaissance Weather Officer) reported that he suspected the presence of multiple centers, but was unable to locate any other areas of light and variable winds that would be associated with such centers.

The following aircraft reconnaissance mission also encountered perturbations in the wind field which indicated the possibility of multiple circulations. Figure 3-15-1 shows Joe as a tropical depression at the time of this mission. The arrow marks the position of the surface circulation located by aircraft. The position of the dominant circulation is not apparent from this imagery, nor is it possible to confirm the presence of multiple circulations. Synoptic data was also inadequate to afford recognition of multiple centers. Figure 3-15-2 is the surface analysis at 100000Z. Major features, such as Typhoon Ida located south of Japan, and the remains of Tropical Storm Herbert located over Indochina, are well defined. Joe appears as a tropical depression in the Philippine Sea, but data density is not sufficient to prove or disprove the presence of multiple circulations.

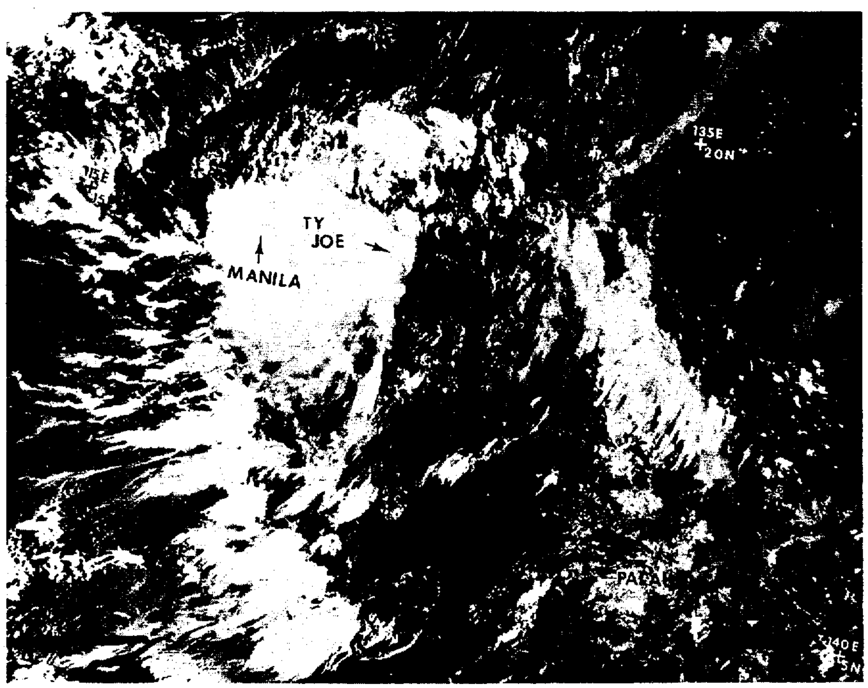


Figure 3-15-1. Satellite imagery at the time of the aircraft reconnaissance mission. (100650Z October NOAA 7 visual imagery).

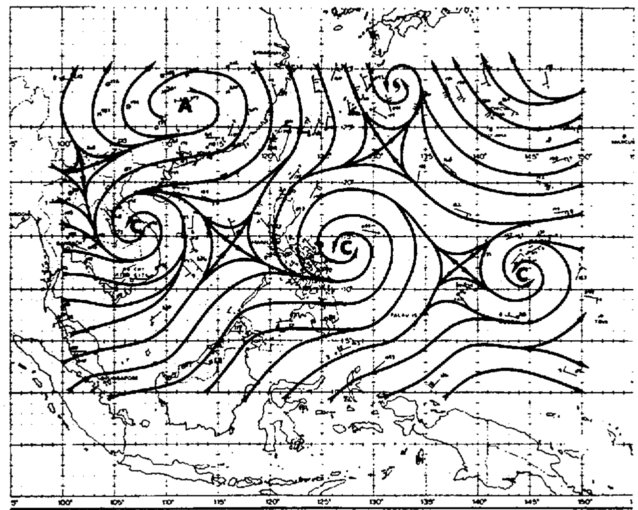


Figure 3-15-2. Surface analysis for 100000Z October showing Typhoon Ida (14W), Tropical Storm Herbert (13W), and Joe (15W) as a tropical depression in the Philippine Sea.

Joe remained poorly organized over the next 24 hours. Figure 3-15-3 illustrates the upper-level conditions which greatly affected Joe's intensity. Strong northeasterly flow to the south of the anticyclone centered near Okinawa created a shearing environment which inhibited Joe's development. This condition, combined with rapid movement over the next 24 hours, resulted in Joe approaching the Philippines as a 30 kt (15 m/s) depression with no increase in organization of intensity. As Joe crossed central Luzon, synoptic data and radar reports indicated that the system was still poorly organized.

After emerging in the South China Sea, Joe became better organized and intensified as it moved in a wide anticyclonic track around the western periphery of the subtropical ridge. Upper-level flow patterns at this time (Figure 3-15-4) were favorable for Joe's development and allowed the formation of well-defined outflow channels to the northeast and southwest. Figure 3-15-5 shows Joe near maximum intensity. Note the symmetrical and unrestricted outflow pattern.

Joe continued to intensify as it moved northwestward reaching a maximum intensity of 65 kt (33 m/s) six hours prior to landfall. Joe dissipated rapidly after moving inland over southern China approximately 100 nm (185 km) west of Hong Kong.

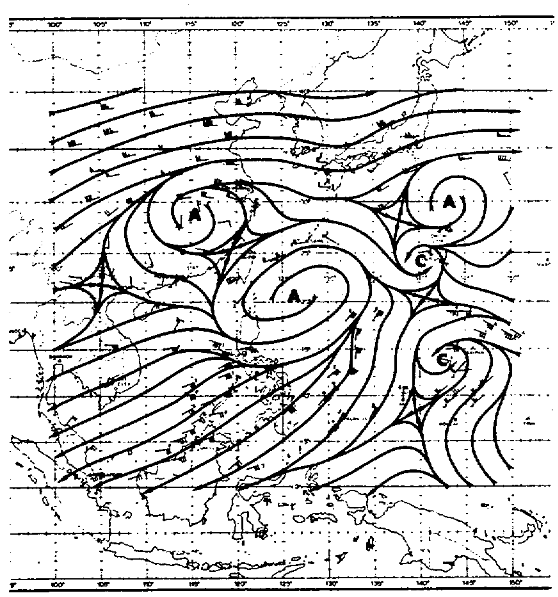


Figure 3-15-3. 200 mb analysis for 100000Z October. Note the strong northeasterly flow in the vicinity of the Philippines.

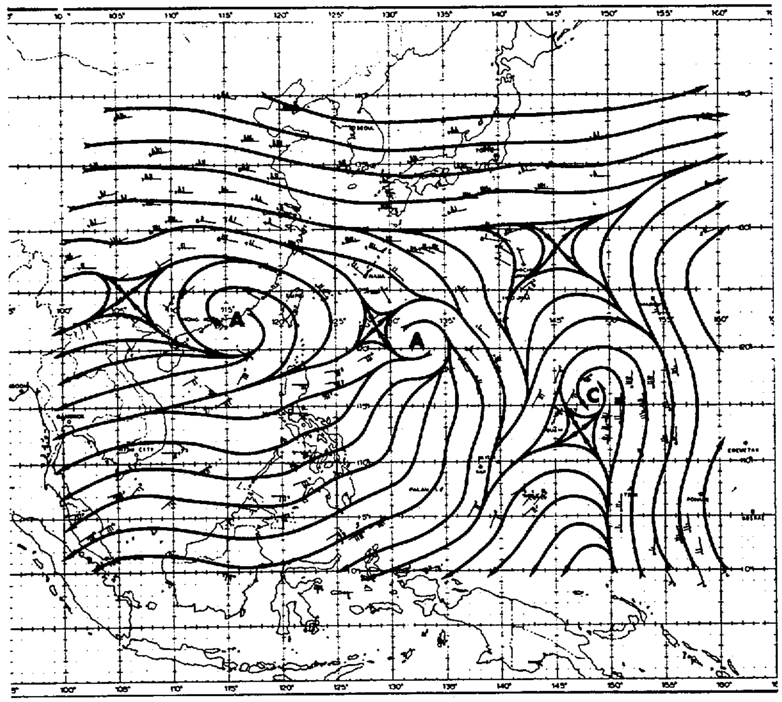


Figure 3-15-4. 200 mb analysis at 131200Z October. Comparison with Figure 3-15-3 shows a displacement of the anticyclone to the north of Joe which allowed the development of outflow channels to the northeast and southwest.

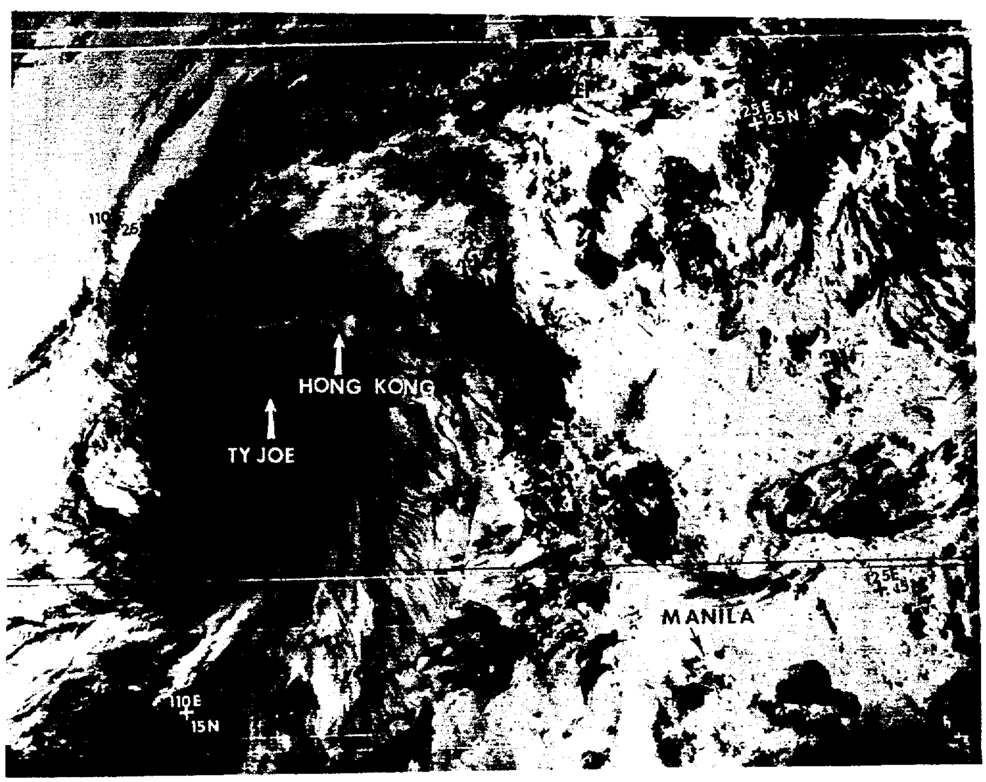


Figure 3-15-5. Typhoon Joe at maximum intensity three hours prior to landfall (131034Z October DMSP infrared imagery).

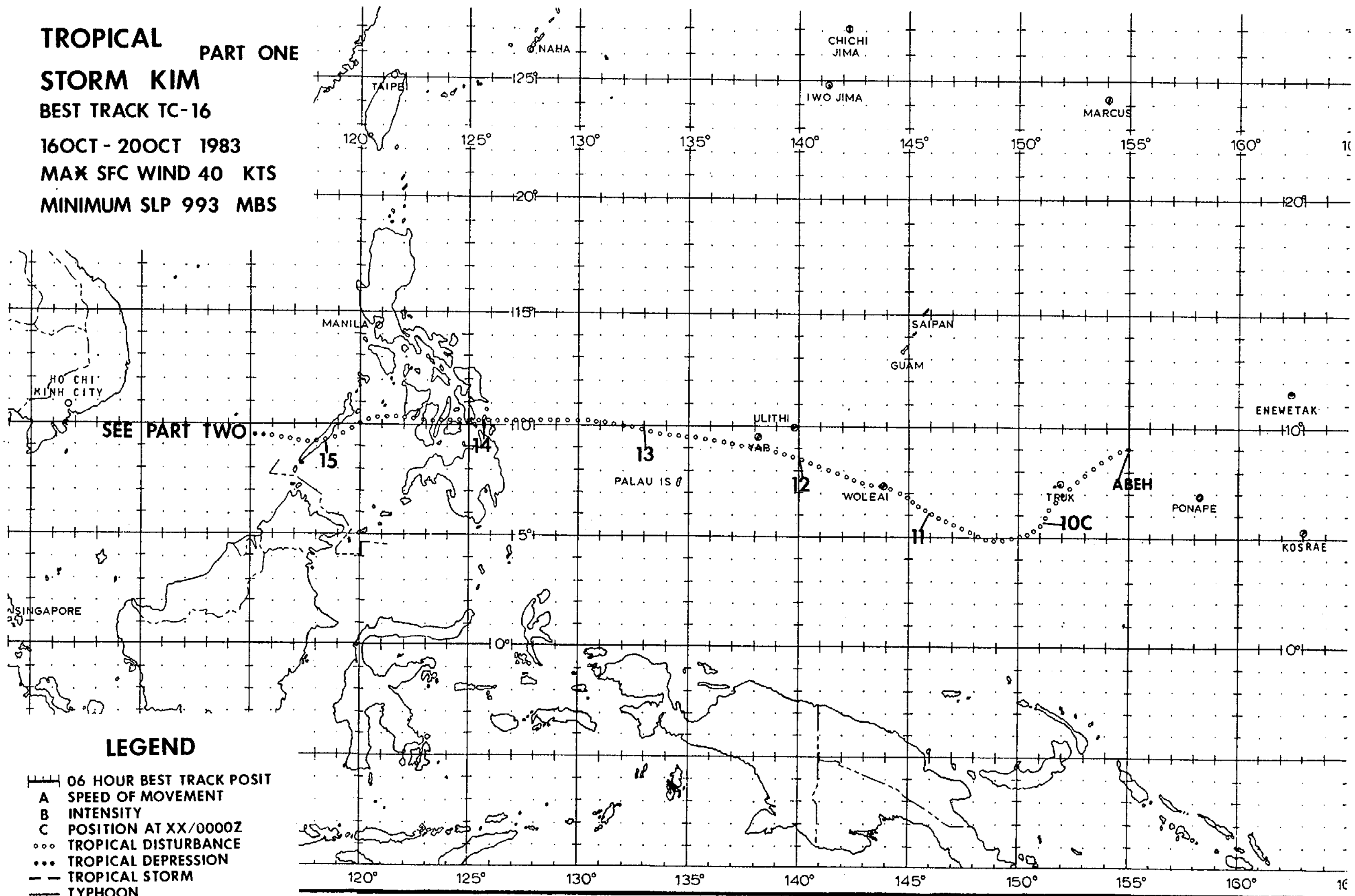
TROPICAL STORM KIM PART ONE

BEST TRACK TC-16

16OCT - 20OCT 1983

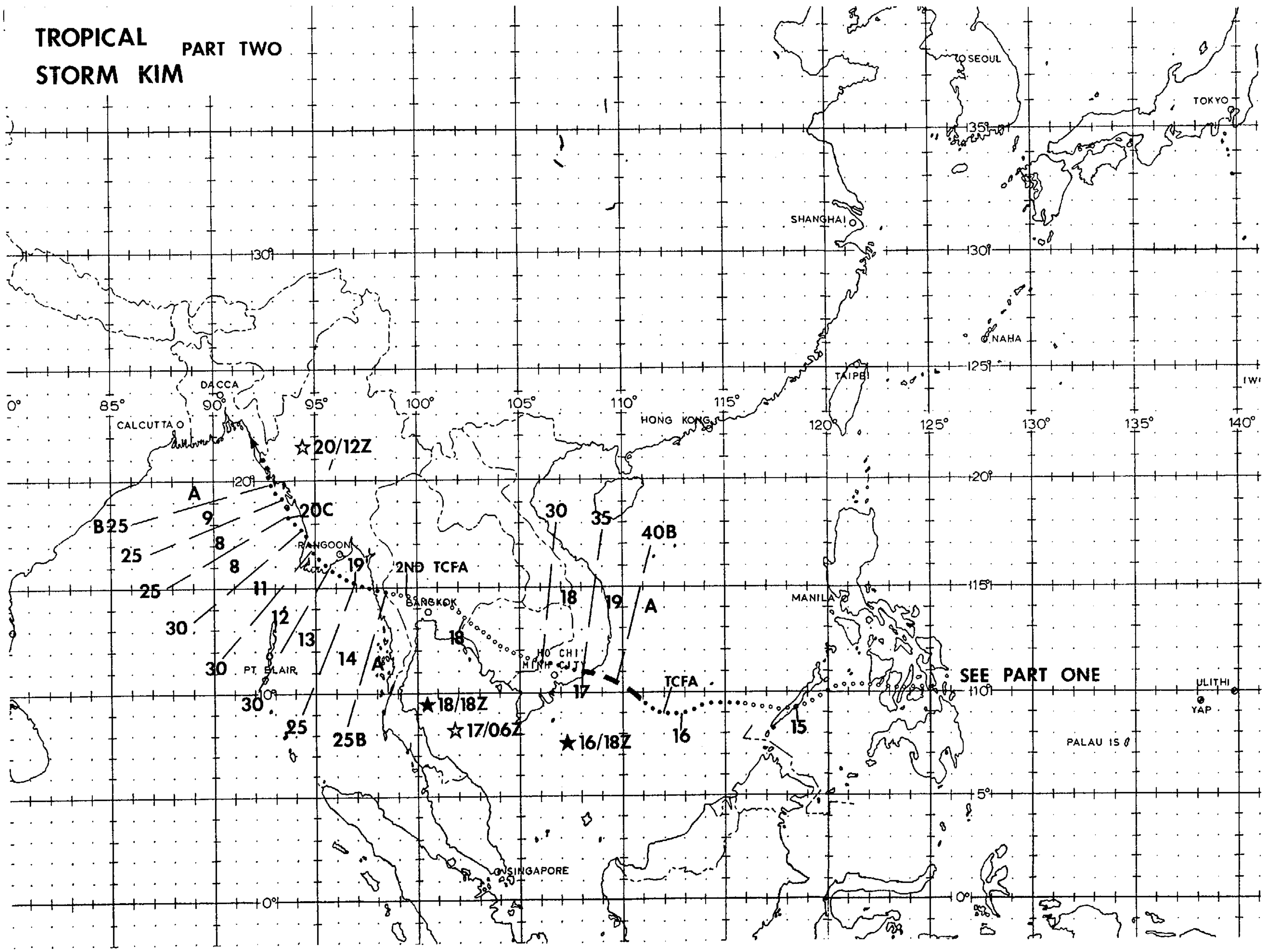
MAX SFC WIND 40 KTS

MINIMUM SLP 993 MBS



LEGEND

- 06 HOUR BEST TRACK POSIT
- A SPEED OF MOVEMENT
- B INTENSITY
- C POSITION AT XX/0000Z
- ○○○ TROPICAL DISTURBANCE
- ••• TROPICAL DEPRESSION
- — — TROPICAL STORM
- —— TYPHOON
- ◆ SUPER TYPHOON START
- ◇ SUPER TYPHOON END
- ◇◇◇ EXTRATROPICAL
- ••• DISSIPATING STAGE
- ★ FIRST WARNING ISSUED
- ☆ LAST WARNING ISSUED



TROPICAL STORM KIM
PART TWO
SEOUL
TOKYO
SHANGHAI
NAHA
TAIPEI
DACCA
CALCUTTA
HONG KONG
RANGOON
BANGKOK
HO CHI MINH CITY
MANILA
PT. BLAIR
SINGAPORE
ULITHI
YAP
PALAU IS
SEE PART ONE
2ND TCFA
TCFA
☆20/12Z
★18/18Z
☆17/06Z
★16/18Z
20C
40B
25B
B25
85°
90°
95°
100°
105°
110°
115°
120°
125°
130°
135°
140°
35°
30°
25°
20°
15°
10°
5°
0°

Tropical Storm Kim was the only tropical cyclone of 1983 to move from the South China Sea, across Indochina, and into the Bay of Bengal. This unusual meteorological event was permitted by the extremely low topographical resistance encountered along the storm's track across Indochina.

Tropical Storm Kim was initially detected on 9 October as a weak tropical disturbance located near 9N 153E. This disturbance was mentioned daily in the Significant Tropical Weather Advisory (ABEH PGTW) as it moved westward over the next four days. Although the disturbance was a persistent feature on satellite imagery, it showed no signs of development and was expected to dissipate over the southern Philippines. On the 14th of October, it appeared that the disturbance was dissipating in the vicinity of the Sulu Sea. At this point, the disturbance had lost its convective signature on satellite imagery and was no longer identifiable as a disturbance. However, on the following day, the system emerged in the South China Sea, developed rapidly into a tropical depression, and moved westward at speeds of 11 to 14 kt (6 to 7 m/s). The southwest monsoon was well-developed over the South China Sea at this time, providing an environment favorable for continued development. In view of Kim's position and the fact that several previous depressions had intensified in this environment, a TCFA was issued at 160459Z.

Kim intensified while transitting the South China Sea, reaching tropical storm intensity at 161200Z. Figure 3-16-1 shows Kim just prior to achieving tropical storm intensity near the coast of Vietnam. The first warning on Kim was issued at 161800Z, five hours prior to landfall on the coast of Vietnam.

Although Kim was a relatively weak tropical storm, its rapid development just prior to landfall resulted in much human suffering. Preliminary reports indicated that more than 200 people, most of them fishermen, died or were lost. Property damage was also unusually high, with 300 boats and ships, 3,000 houses, and 19,750 acres (8,000 hectares) of rice destroyed.

Warnings on Kim were suspended shortly after landfall as the circulation weakened rapidly over land. Kim was downgraded to a tropical depression at 170600Z as it crossed the border from Vietnam into Kampuchea. Six hours later it was classified as a tropical disturbance.

Kim continued tracking across Indochina with a great deal of associated convection and some indications of a middle to lower level circulation apparent in visual satellite imagery. Kim's ability to maintain its intensity during this period may be attributed to the flat terrain encountered along its track and the fact that it was never more than 100 nm (185 km) from water.

A second TCFA was issued for Kim at 181359Z when it became apparent that the disturbance would move into the Andaman Sea where regeneration was considered likely. Warnings for Kim were resumed on the following day as tropical depression intensity was achieved over the Andaman Sea (Figure 3-16-2). At this time, Kim was expected to cross the southern tip of Burma and further intensify in the Bay of Bengal. Kim moved across southern Burma as expected but never actually got out over open water in the Bay of Bengal. Instead, Kim moved northward along the coast of Burma, parallel to the axis of the Arakan Mountain Range, and weakened steadily. The final warning was issued as the system dissipated on the 20th at 1200Z.

Figure 3-16-1. Kim as a tropical depression just prior to reaching tropical storm intensity off the coast of Vietnam (160708Z October NOAA 7 visual imagery).

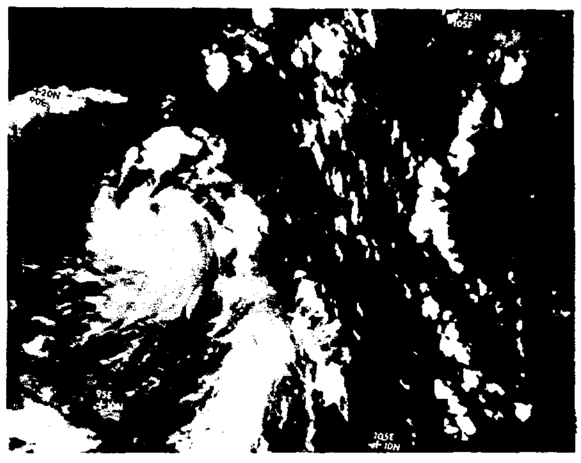
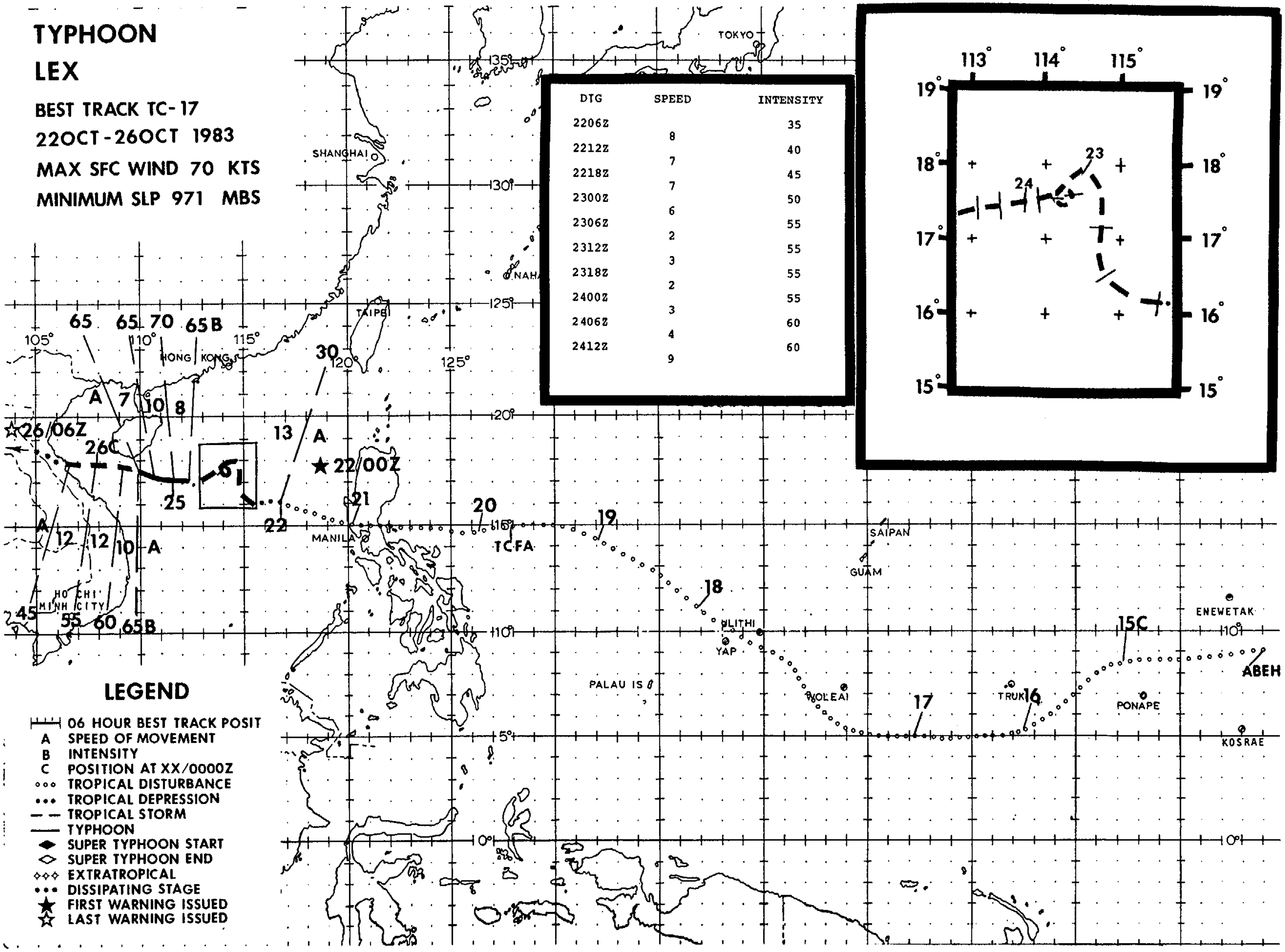


Figure 3-16-2. Tropical Cyclone 16W (Kim) after regeneration in the Andaman Sea (190821Z October NOAA 7 visual imagery).

TYPHOON LEX

BEST TRACK TC-17
22OCT-26OCT 1983
MAX SFC WIND 70 KTS
MINIMUM SLP 971 MBS



DTG	SPEED	INTENSITY
2206Z		35
	8	
2212Z		40
	7	
2218Z		45
	7	
2300Z		50
	6	
2306Z		55
	2	
2312Z		55
	3	
2318Z		55
	2	
2400Z		55
	3	
2406Z		60
	4	
2412Z		60
	9	

LEGEND

- 06 HOUR BEST TRACK POSIT
- A SPEED OF MOVEMENT
- B INTENSITY
- C POSITION AT XX/0000Z
- ○○○ TROPICAL DISTURBANCE
- ••• TROPICAL DEPRESSION
- — — TROPICAL STORM
- —— TYPHOON
- ◆ SUPER TYPHOON START
- ◇ SUPER TYPHOON END
- ◇◇◇ EXTRATROPICAL
- ••• DISSIPATING STAGE
- ★ FIRST WARNING ISSUED
- ☆ LAST WARNING ISSUED

The tropical disturbance which became Lex was extremely slow in developing and achieved Typhoon intensity for a period of only one day. Yet it was one of the most damaging cyclones of the season, responsible for the loss of a ship in the South China Sea and extensive suffering in central Vietnam where it eventually made landfall.

Lex was monitored as a tropical disturbance for eight days prior to issuance of the first warning on the system as a tropical depression. It was first detected in the vicinity of the Marshall Islands on 14 October when satellite imagery revealed the presence of an area of active convection near 9N 164E. Synoptic data in the area at this time indicated that there was not a surface circulation associated with the disturbance but did indicate a 24-hour drop of one to two millibars in sea-level pressure at nearby stations.

The disturbance underwent diurnal fluctuations in its convection as it moved westward but showed no signs of increasing in intensity until the 16th. On the 16th, while located near Truk (WMO 91334) at 5N 151E, an upper-level anticyclone began to develop over the disturbance and the system became better organized.

Over the next three days, the disturbance continued to intensify slowly as it moved westward across the Philippine Sea. Satellite imagery during this period indicated that the upper-level anticyclone was continuing to develop and that convective activity associated with the disturbance was increasing in size, organization, and intensity. Synoptic data indicated the presence of a weak 10 to 15 kt (5 to 8 m/s) surface circulation with an MSLP of 1008 mb.

A TCFA was issued for this disturbance at 192000Z as it approached the Philippines approximately 180 nm (333 km) northeast of Cataduenas Island. A reconnaissance aircraft was dispatched to the area at this time but was unable to close off a surface circulation. The alert was reissued twice as JTWC monitored the progress of this disturbance while it was crossing the central Philippines. The topography of the Philippine Islands had little effect on the disturbance and it emerged in the South China Sea with no appreciable decrease in its organization.

Lex began to intensify while moving west-northwestward away from Luzon. The first warning on Lex was issued on the 22nd at 0000Z when satellite imagery indicated that the cloud bands associated with the system were taking on a comma-shaped appearance. Although Lex was designated as a tropical depression on the initial warning, upgrade to tropical storm status followed quickly when a reconnaissance aircraft encountered 35 kt (18 m/s) winds while fixing the system at 220535Z.

Lex was expected to continue intensifying slowly and move west-northwestward toward Hai-Nan island along the southern periphery of the subtropical ridge. This scenario appeared to be inaccurate when Lex began moving slowly northward after 220600Z. This slow northward movement culminated in a counter-clockwise loop near 17.5N 114.5E, approximately 300 nm (556 km) south of Hong Kong. The movement of Lex during this period was in response to the passage of a developing mid-level trough over China. This trough penetrated farther to the south than was expected, causing a weakness to develop in the subtropical ridge to the north of Lex. It appeared that this trough would cause a complete breakdown of the ridge to the north of Lex, allowing the storm to drift northward toward Hong Kong. Figure 3-17-1 shows the position of this trough as Lex began its cyclonic loop. The interaction of Lex with this trough was also apparent in satellite imagery at the time (Figure 3-17-2). Twelve hours after this scenario was adopted on the 230600Z warning, the subtropical ridge re-established itself to the north of Lex and the storm resumed a westward track.

Lex intensified while moving westward, reaching a maximum intensity of 70 kt (36 m/s) at 0000Z on the 25th. Gradual weakening occurred over the next 24 hours as Lex passed to the south of Hai-Nan island. The interaction of the circulation with the rugged terrain of Hai-Nan had a pronounced effect on the system. The decrease in organization and convection, apparent from satellite imagery, led to the downgrade of Lex to tropical storm status at 251800Z. Lex weakened further while transitting the Gulf of Tonkin, making landfall near Dong Hoi, Vietnam with maximum sustained winds of 50 kt (26 m/s). Lex dissipated rapidly over the rugged terrain of central Vietnam and Laos after causing extensive damage to low-lying areas in its path.

According to preliminary reports from Vietnam, areas near the point of landfall were devastated by the high winds and torrential rains associated with Lex. Damage was extensive as rivers rose six feet (2 m), resulting in widespread flooding. Hundreds of people were killed or injured, 17,000 homes were destroyed, and six hospitals were seriously damaged. In addition, an estimated 100,000 tons of starch food may have been lost due to the flooding.

Other damage caused by Lex came to light after the dissipation of the storm. The oil drilling ship, Glomar Java Sea, was operating in the vicinity of Hai-Nan island during the passage of Lex. A search was conducted for the ship after radio contact was lost during the storm. The 5,926 ton vessel was finally located using sonar under 300 ft (91 m) of water about 60 nm (111 km) south of Hai-Nan island. There have been no reports of survivors from the crew of 81.

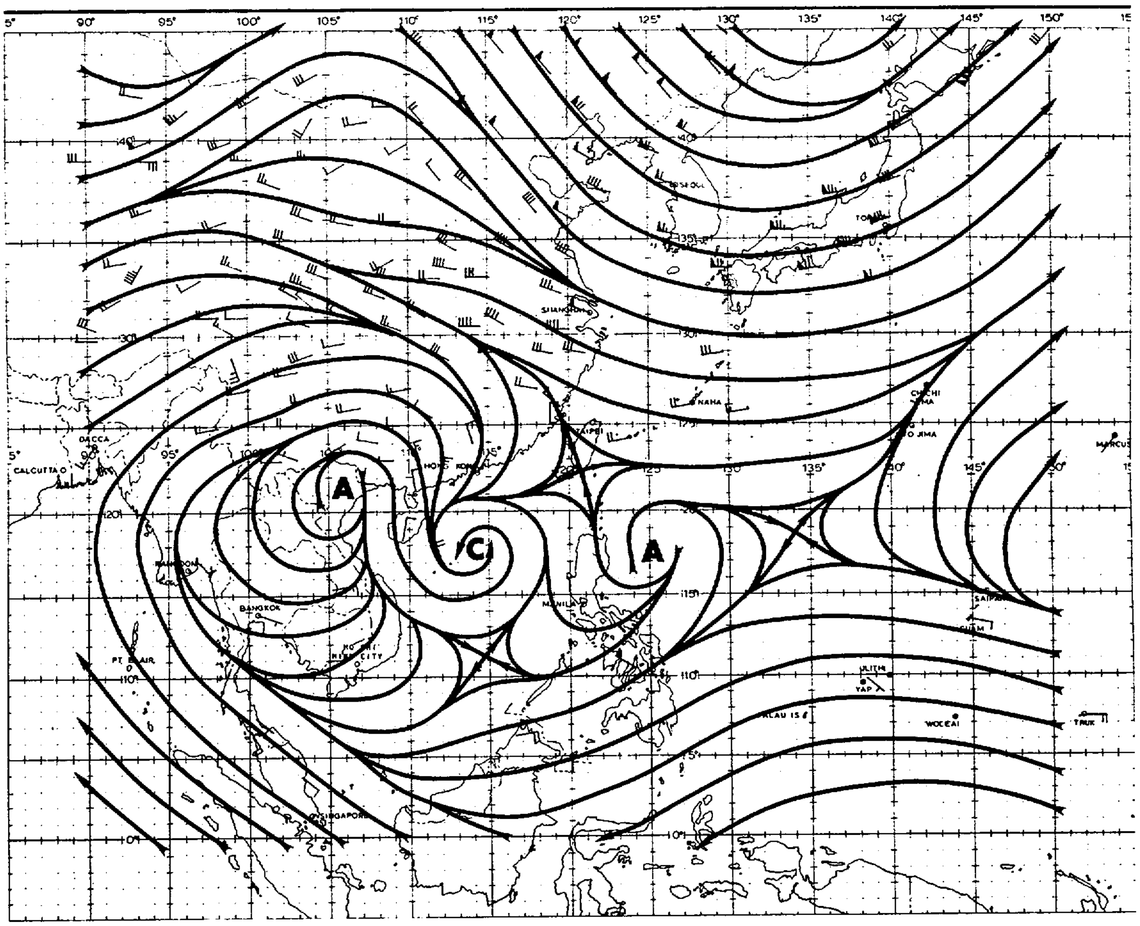


Figure 3-17-1. Orientation of the mid-level trough which briefly interacted with Lex (230000Z October 500 mb analysis).

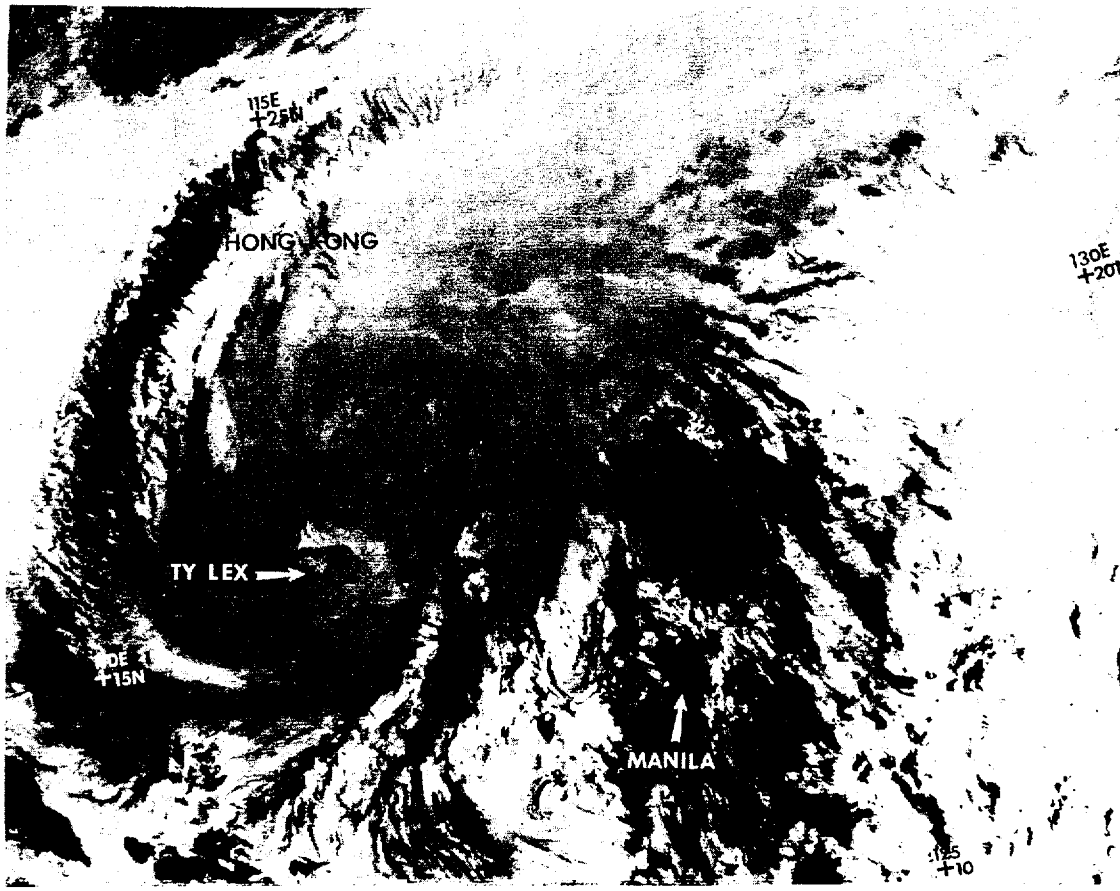
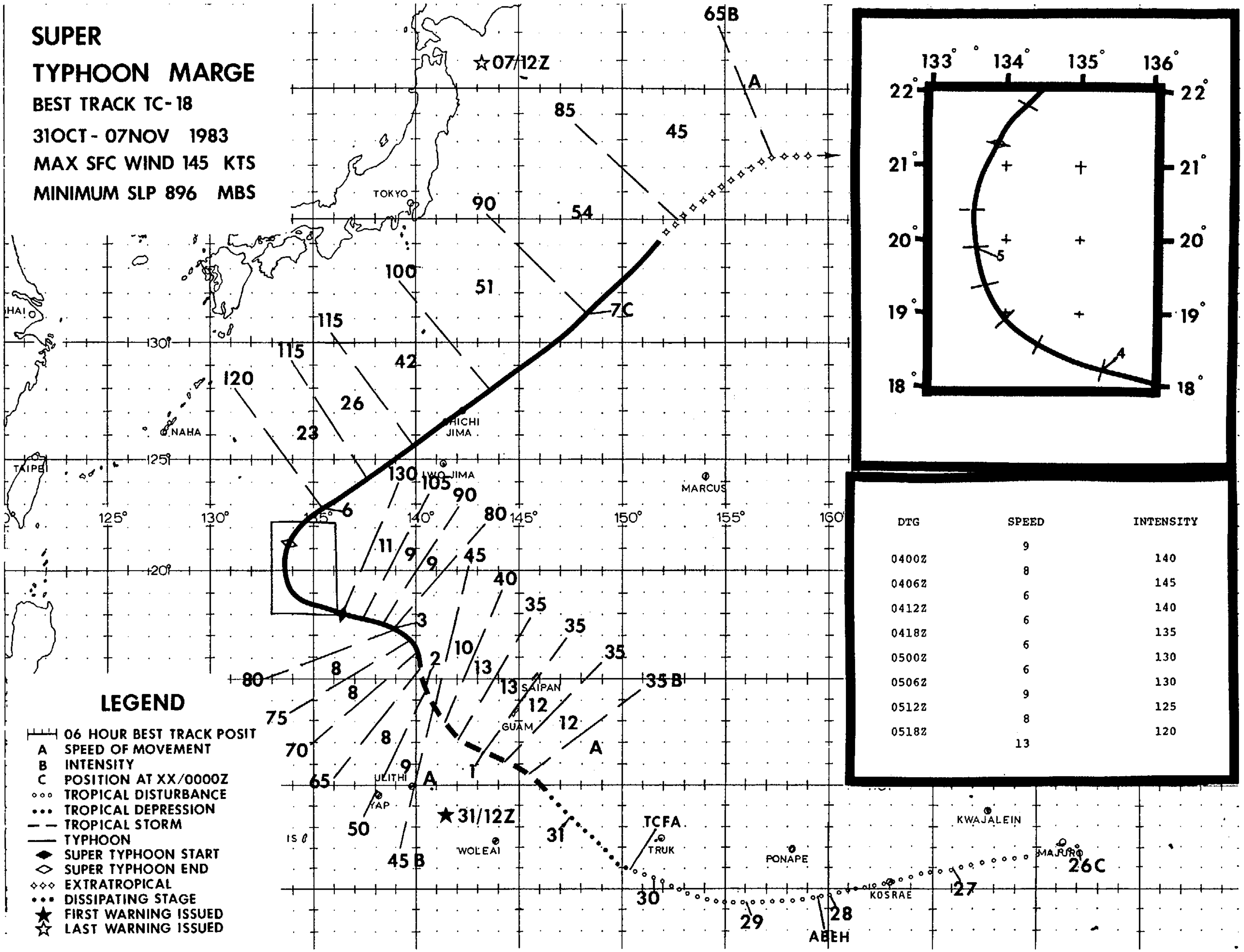


Figure 3-17-2. Lex as a tropical storm while undergoing a cyclonic loop (231026Z October DMSP infrared imagery).



DTG	SPEED	INTENSITY
	9	
0400Z		140
	8	
0406Z		145
	6	
0412Z		140
	6	
0418Z		135
	6	
0500Z		130
	6	
0506Z		130
	9	
0512Z		125
	8	
0518Z		120
	13	

The tropical disturbance which developed into the fourth super typhoon of the season was initially detected on 26 October as an area of unorganized convection associated with a weak surface circulation near 7N 172E. Synoptic data at the time indicated that surface winds associated with the disturbance were weak, 5-10 kt (3-5 m/s) and MSLP was 1012 mb. This disturbance organized slowly over the next four days as it moved westward along the monsoon trough axis. During this period, an upper-level anticyclone formed in close proximity to the low-level circulation. This development was accompanied by a drop in MSLP to 1008 mb and a concurrent increase in the convective activity associated with the circulation. This led to the issuance of a TCFA on the 30th at 1035Z.

During the 24 hour period following the issuance of the TCFA, satellite imagery showed that the convective activity associated with the circulation was undergoing further consolidation and that outflow channels were developing to the northeast and southwest. Synoptic data and Dvorak satellite analysis indicated maximum sustained winds of 25 to 35 kt (13-18 m/s), prompting the issuance of the first warning at 311200Z.

At this point, Marge was located 180 nm (333 km) south of Guam. The subtropical ridge in this area was expected to weaken in response to the passage of an intense mid-latitude trough. Forecasts issued during this period projected that Marge would react to the passage of this trough, moving slowly northwestward, then recurving to the northeast. Marge moved northwestward as expected, but did not recurve. By the time Marge arrived in a position to recurve in advance of the trough, the trough had already passed to the north and Marge came under the influence of low-level easterly flow associated with a high upstream of the trough. This resulted in Marge resuming a northwestward track prior to subsequent recurvature in advance of another mid-latitude trough.

Premature adoption of the recurvature scenario greatly affected the accuracy of the intensity forecasts. Marge achieved typhoon intensity on 2 October at 0600Z. This was not far from the forecast intensity for this time. However, two days later, on the 4th, Marge was a 145 kt (75 m/s) super typhoon. Since, by the 4th, Marge was initially expected to be weakening after recurvature, unusually large intensity errors occurred.

Shorter range intensity forecasts met with greater success. Use of an objective aid for the prediction of explosive deepening (Dunnavan, 1981) resulted in fairly accurate 24 hour intensity forecasts verifying at maximum intensity. At 0600Z on the 3rd, this technique predicted that Marge would undergo explosive deepening. Within 24 hours of this prediction, Marge's intensity increased from 90 kt (46 m/s) to 145 kt (75 m/s). Marge did not recurve initially as forecast and, when recurvature did occur, moved at speeds much higher than anticipated while rapidly

Figure 3-18-1. Marge in the early stages of recurvature. At this point, maximum sustained winds were 115 kt (59 m/s) and speed of movement was 25 kt (46 km/hr) (060611Z November NOAA 7 visual imagery).

evolving into an extratropical system. This resulted in large position errors. Figure 3-18-1 and 3-18-2 give some indication of the rapidity with which Marge underwent extratropical transition. Although there is only 17 hours elapsed time between the two pictures, there is a striking difference in Marge's appearance. In Figure 3-18-1, Marge appears as a well developed typhoon with a circular eye and maximum sustained winds of 115 kt (59 m/s). In Figure 3-18-2, Marge is nearing the end of its transition to an extratropical system while moving northeastward at a speed of 51 kt (95 km/hr).

Marge's high speed of movement during recurvature was phenomenal. At 051200Z, the forecast called for recurvature with acceleration to a maximum speed of 35 knots. This forecast predicted that Marge would more than quadruple its speed of forward motion since the storm was only moving at 8 kt (15 km/hr) at the time. However, this forecast fell far short of the 54 kt (100 km/hr) speed actually attained by Marge.

Marge's high speed of movement following recurvature contributed to the deformation of the wind field associated with the storm. Marge became very asymmetric, with winds in its southeast semicircle much higher than winds in the northwest semicircle. This was due to the addition of its speed of translation to the circulation wind field on the southeastern side and the corresponding decrease in winds on the northwestern side. This made it appear that Marge's circulation weakened more slowly than it actually did since the measure of the intensity of a system is the maximum surface wind, without regard to symmetry.

The asymmetric nature of Marge's wind field proved beneficial to the crew of the Colombian Navy Sailing Ship ARC Gloria. Gloria was fortunate enough to encounter the weak northwestern portion of Marge's circulation. Even so, Gloria reported seas to 30 ft (9 m) and winds gusting to 90 kt (46 m/s) as Marge passed to the southeast. The high winds and heavy seas encountered by Gloria resulted in the injury of three crewmen, the loss of a motor boat and five sails, and minor structural damage.

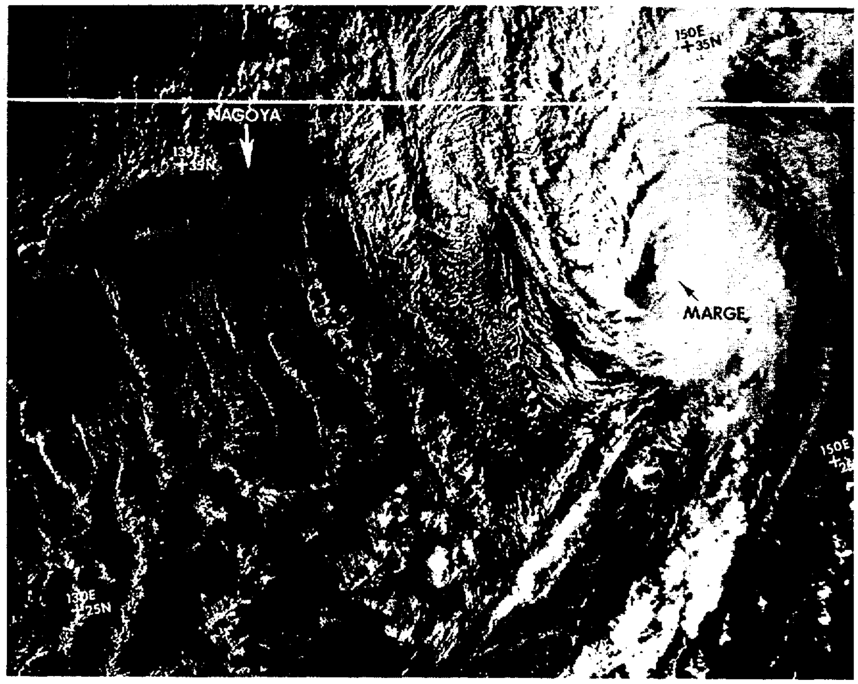
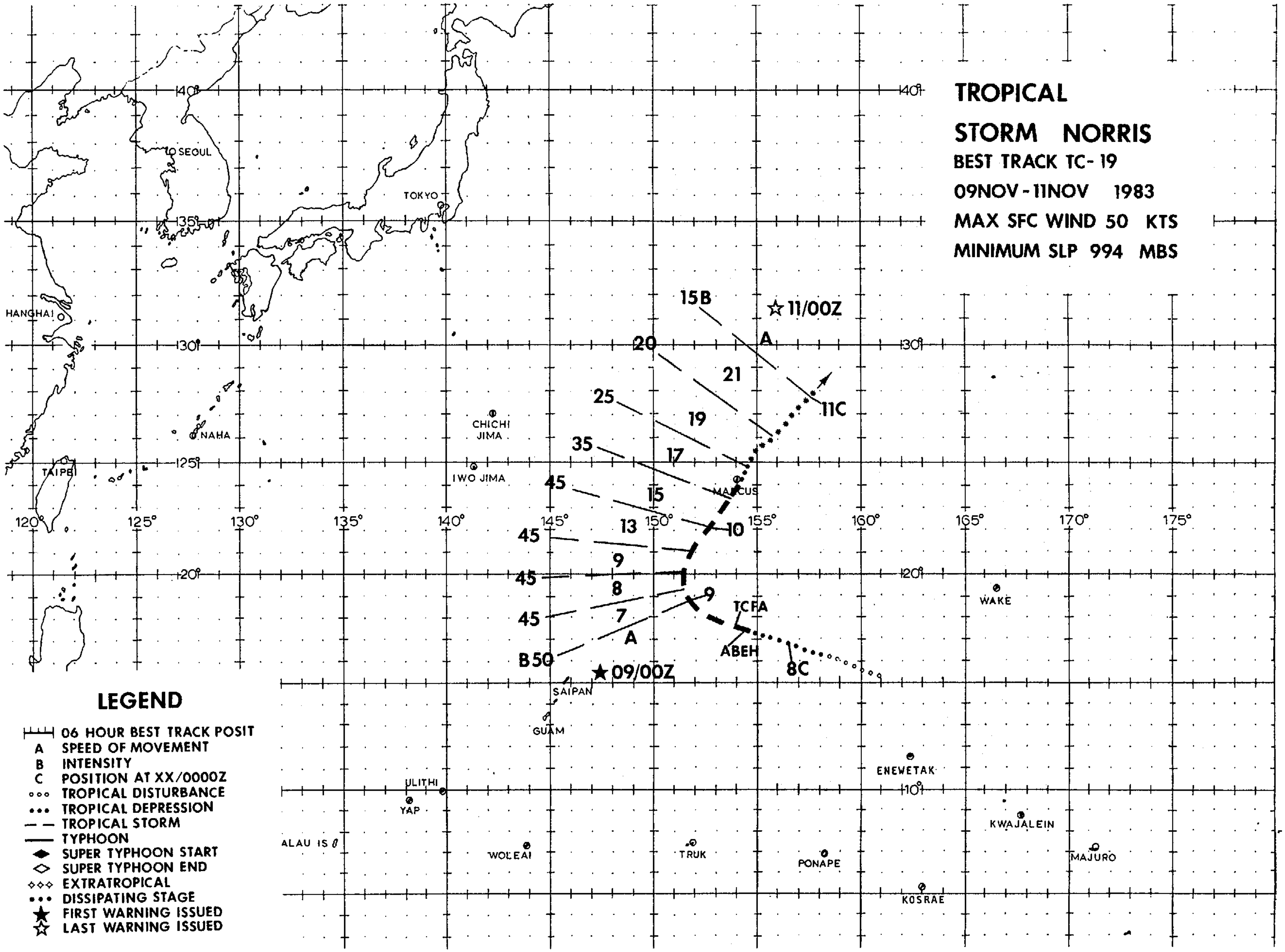


Figure 3-18-2. Marge just prior to completing transition to an extratropical system. Maximum sustained winds were 90 kt (46 m/s) and speed of movement was 51 kt (95 km/hr) (062254Z November NOAA 8 visual imagery).


TROPICAL
STORM NORRIS
BEST TRACK TC-19
09NOV-11NOV 1983
MAX SFC WIND 50 KTS
MINIMUM SLP 994 MBS
LEGEND
06 HOUR BEST TRACK POSIT
A SPEED OF MOVEMENT
B INTENSITY
C POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
DISSIPATING STAGE
FIRST WARNING ISSUED
LAST WARNING ISSUED
SEOUL
TOKYO
HANGHAI
NAHA
TAIPEI
CHICHI JIMA
IWO JIMA
MARCUS
WAKE
SAIPAN
GUAM
ULITHI
YAP
ALAU IS
WOLEAI
TRUK
PONAPE
KOSRAE
ENEWETAK
KWAJALEIN
MAJURO
15B
☆11/00Z
A
20
21
11C
25
19
35
17
45
15
13
10
45
9
45
8
9
TCFA
45
7
A
ABEH
B50
★09/00Z
8C
40°
35°
30°
25°
20°
10°
120°
125°
130°
135°
140°
145°
150°
155°
160°
165°
170°
175°

TROPICAL STORM NORRIS (19W)

On the day following the final warning on Super Typhoon Marge, a surface circulation appeared on visual satellite imagery to the east of the front associated with the remnants of Marge. This circulation was located in a data sparse area and had very little associated convective activity. Although depicted as small and unimpressive on the satellite imagery, the circulation quickly evolved into a midget tropical storm. A TCFA was issued at 080849Z when the deformation of the low-level cloud-lines on satellite imagery indicated that the circulation was well organized. A reconnaissance aircraft was dispatched on the following morning to investigate. When the aircraft arrived at the expected position of the circulation, it encountered light and variable winds with no indication of the presence of a surface circulation. Upon receipt of this report from the aircraft, the expected position was revised on the basis of updated satellite imagery and the aircraft was vectored eastward to a new position. Only 130 nm (241 km) to the east-southeast of its previous position, the aircraft encountered a well-developed tropical storm with 50 kt (26 m/s) winds and a circular eye 15 nm (28 km) in diameter. The first warning on Tropical Storm Norris was issued upon receipt of this report. Figure 3-19-1 shows Norris at the time of the reconnaissance mission. Although an eye is not apparent on satellite imagery, Norris does appear as a highly organized (though extremely small) tropical storm.

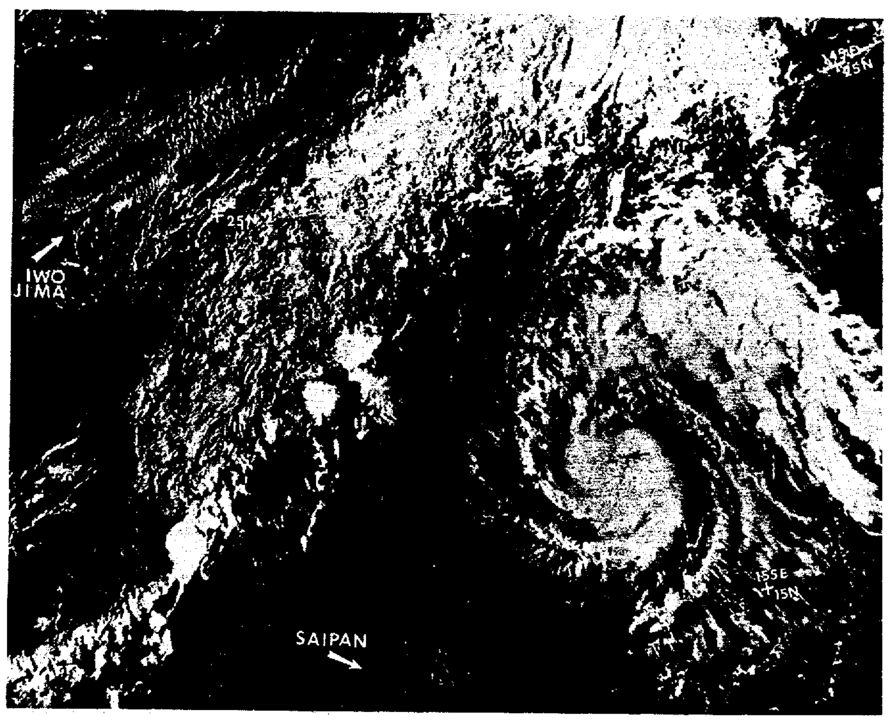


Figure 3-19-1. Tropical Storm Norris at maximum intensity just prior to recurvature. Less than 48 hours later, Norris was completely absorbed by the front which appears to the left in the picture (082211Z November NOAA 8 visual imagery).

The position of Norris, to the east of an advancing front, led to a straightforward forecast of recurvature and dissipation which verified well. Less than three days after its initial detection, Norris had been completely absorbed by the advancing front and was no longer identifiable as a distinct entity.

Post-analysis revealed that Norris developed rapidly from a pre-existing disturbance of small proportions. Figure 3-19-2 shows Norris at 080931Z, near the time of issuance of the TCFA. Although there is little convective activity associated with the circulation, the organization of the low-level wind field is evident in the alignment of the cloud lines. This low-level banding is also evident in visual satellite imagery 12 hours prior to the TCFA. However, imagery prior to that shows only a small unorganized disturbance moving rapidly northwestward. Norris' rapid development was, in part, due to favorable upper-level conditions which existed at that time. Figure 3-19-3 shows that Norris developed in an area of light but highly divergent upper-level flow.

Norris never posed a threat to any major land mass but was a subject of great concern to shipping in the area. Fortunately, Norris' movements were accurately forecasted and the ships involved were able to avoid the tiny but powerful circulation.

Figure 3-19-2. Norris at the time of issuance of the TCFA (080931Z November NOAA 8 infrared imagery).

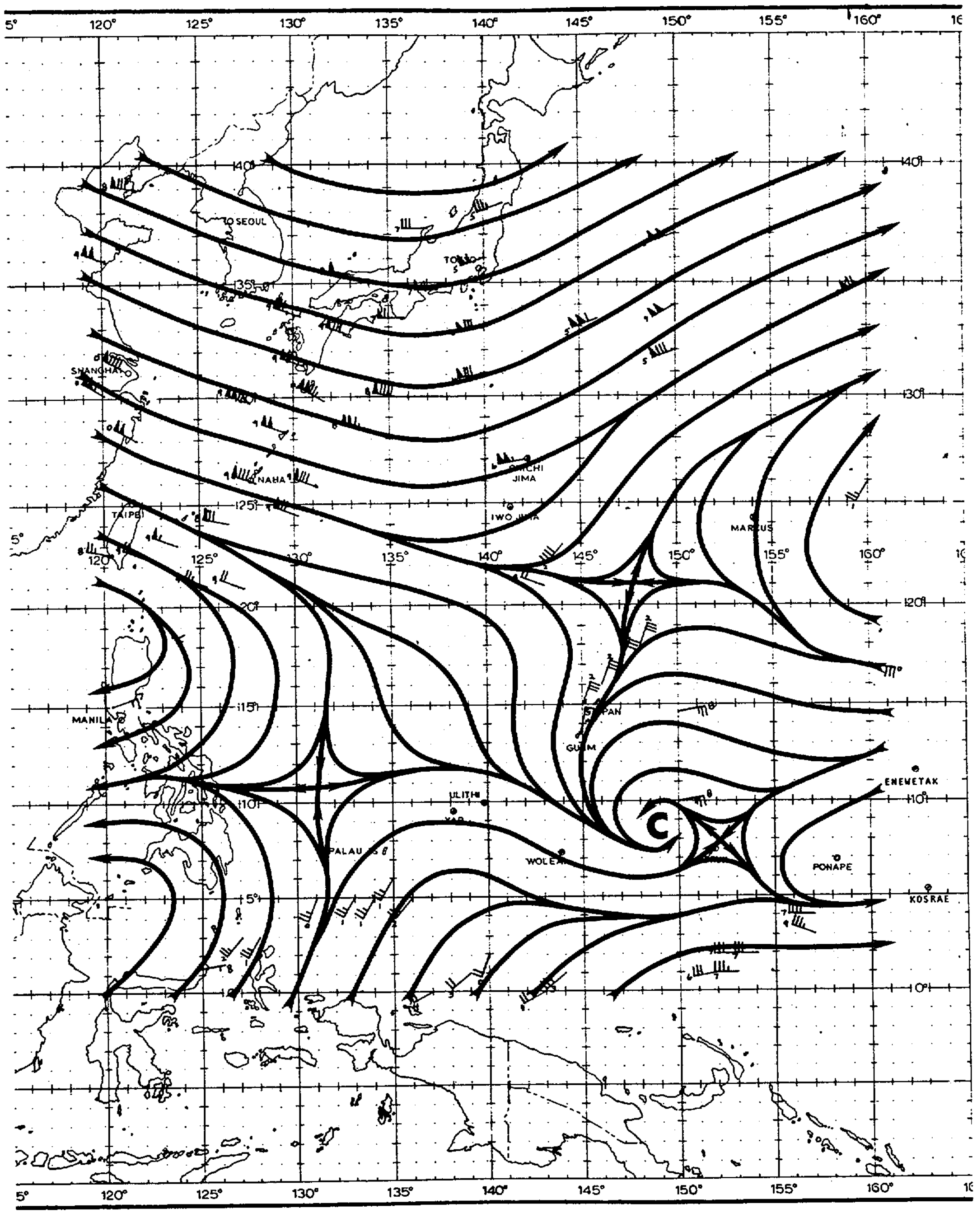
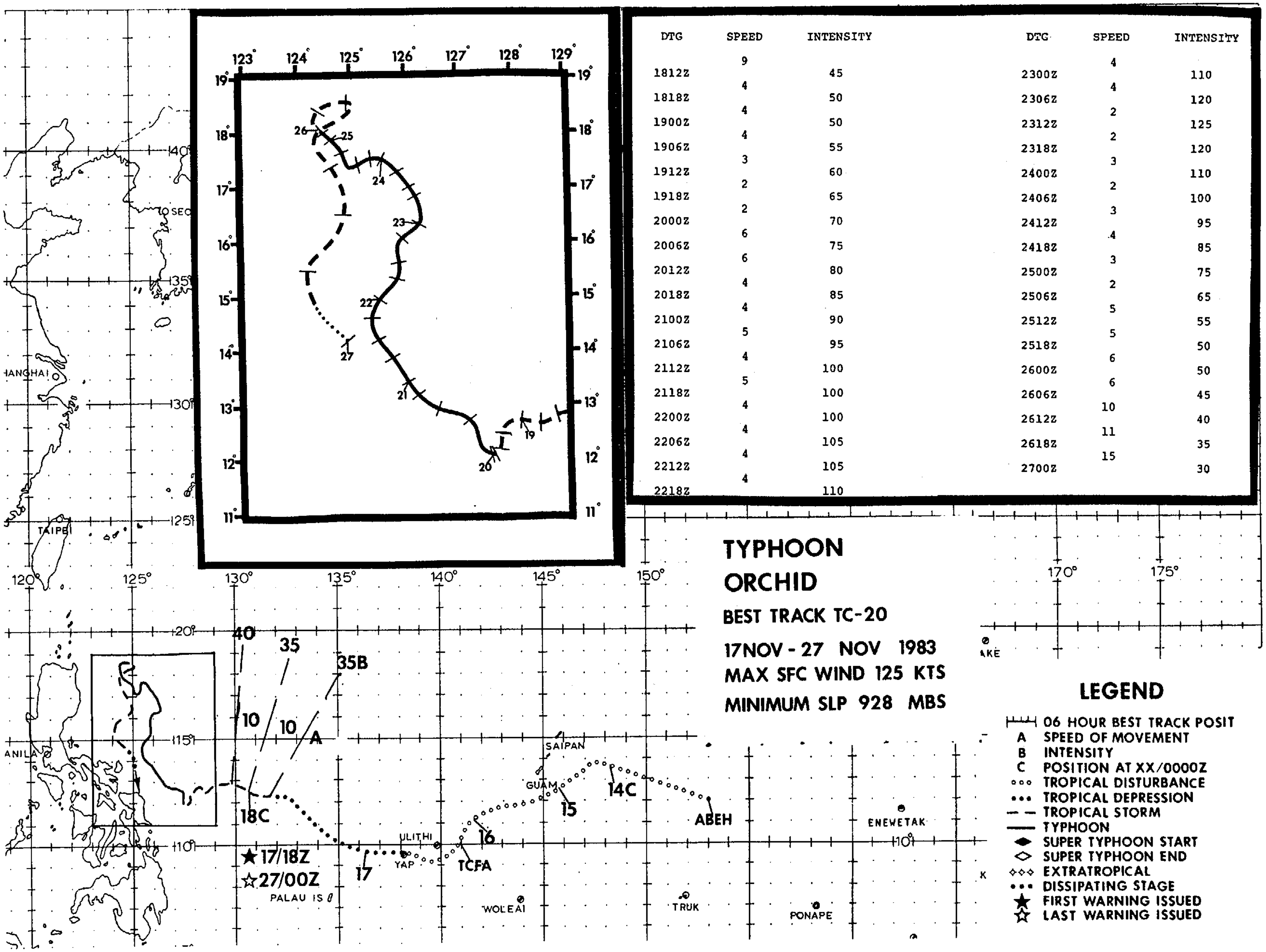


Figure 3-19-3. Norris formed in an area of light but highly divergent upper-level flow to the northeast of a TUTT cell (081200Z November 200 mb analysis).



DTG	SPEED	INTENSITY
	9	
1812Z		45
	4	
1818Z		50
	4	
1900Z		50
	4	
1906Z		55
	3	
1912Z		60
	2	
1918Z		65
	2	
2000Z		70
	6	
2006Z		75
	6	
2012Z		80
	4	
2018Z		85
	4	
2100Z		90
	5	
2106Z		95
	4	
2112Z		100
	5	
2118Z		100
	4	
2200Z		100
	4	
2206Z		105
	4	
2212Z		105
	4	
2218Z		110

DTG	SPEED	INTENSITY
	4	
2300Z		110
	4	
2306Z		120
	2	
2312Z		125
	2	
2318Z		120
	3	
2400Z		110
	2	
2406Z		100
	3	
2412Z		95
	4	
2418Z		85
	3	
2500Z		75
	2	
2506Z		65
	5	
2512Z		55
	5	
2518Z		50
	6	
2600Z		50
	6	
2606Z		45
	10	
2612Z		40
	11	
2618Z		35
	15	
2700Z		30

TYPHOON ORCHID

BEST TRACK TC-20

17NOV - 27 NOV 1983
MAX SFC WIND 125 KTS
MINIMUM SLP 928 MBS

LEGEND

- 06 HOUR BEST TRACK POSIT
- A SPEED OF MOVEMENT
- B INTENSITY
- C POSITION AT XX/0000Z
- ◦◦◦ TROPICAL DISTURBANCE
- ••• TROPICAL DEPRESSION
- — — TROPICAL STORM
- —— TYPHOON
- ◆ SUPER TYPHOON START
- ◇ SUPER TYPHOON END
- ◇◇◇ EXTRATROPICAL
- ••• DISSIPATING STAGE
- ★ FIRST WARNING ISSUED
- ☆ LAST WARNING ISSUED

Typhoon Orchid was the first of three tropical cyclones to develop in the western North Pacific during mid-November. This flurry of activity in the northern hemisphere was accompanied by the development of two tropical cyclones in the southern hemisphere, Tropical Cyclone 04S and Tropical Cyclone 05S (Quenton). The establishment of strong low-level westerlies at low latitudes on both sides of the equator preceded the onset of activity.

Orchid developed from a tropical disturbance which was first detected on the 12th of November as an area of convective activity located 300 nm (556 km) north of Truk (WMO 91334). The disturbance moved southwestward over the next three days as its convection increased in intensity and size. The first aircraft reconnaissance mission to investigate the disturbance was conducted on 15 November while the disturbance was located 170 nm (315 km) southwest of Guam (WMO 91212). This mission did not succeed in closing off a circulation and indicated that the disturbance was a broad area of low pressure (MSLP of 1004 mb) with maximum sustained surface winds of 25 kt (13 m/s). Later satellite imagery indicated that the disturbance was becoming better organized. An increase in convective activity, accompanied by the development of an upper-level anticyclone led to the issuance of a TCFA at 0300Z on the 16th. A second aircraft reconnaissance mission, on the 17th, was also not able to close off a circulation and provided data indicating that there was little change in intensity from the previous mission. This information did not correlate with observations from satellite imagery which continued to show a marked increase in the organization of the system. Post-analysis revealed that the aircraft was investigating features not associated with the dominant circulation to the northwest. The first warning on Orchid as a tropical storm was issued at 1800Z on the 17th when intensity estimation by satellite indicated that maximum sustained winds were in the 40-45 kt (21-23 m/s) range.

Orchid's movement from this point on was highly erratic. Strong low-level northeasterlies were opposed at higher levels by southwesterly flow which resulted in a continual conflict in steering. This complex environment was further complicated by the development of Typhoon Percy in the South China Sea (Figure 3-20-1). The separation distance between Orchid and Percy remained constant at 850 nm (1574 km) throughout the period of their coexistence. Although there was not a Fujiwhara interaction observed in this case, the possibility of interaction was under constant consideration by JTWC forecasters.

In spite of the effects of vertical shear experienced by Orchid and Percy, both systems achieved typhoon intensity. Orchid's maximum intensity of 125 kt (64 m/s) was accompanied by an MSLP of 928 mb measured by aircraft on the 23rd. However, both systems eventually succumbed to the effects of vertical shear. Two days after reaching maximum intensity, Orchid had weakened significantly. Although maximum sustained winds were 55 kt (28 m/s), MSLP was up to 995 mb. Winds associated with Orchid were higher than might be expected for a circulation with such a high central pressure because ambient low-level flow was particularly strong. Gale force northeasterlies on the northwest side of Orchid's circulation augmented the winds on that side, resulting in a band of high winds which were much stronger than the winds on the southeast side of the circulation.

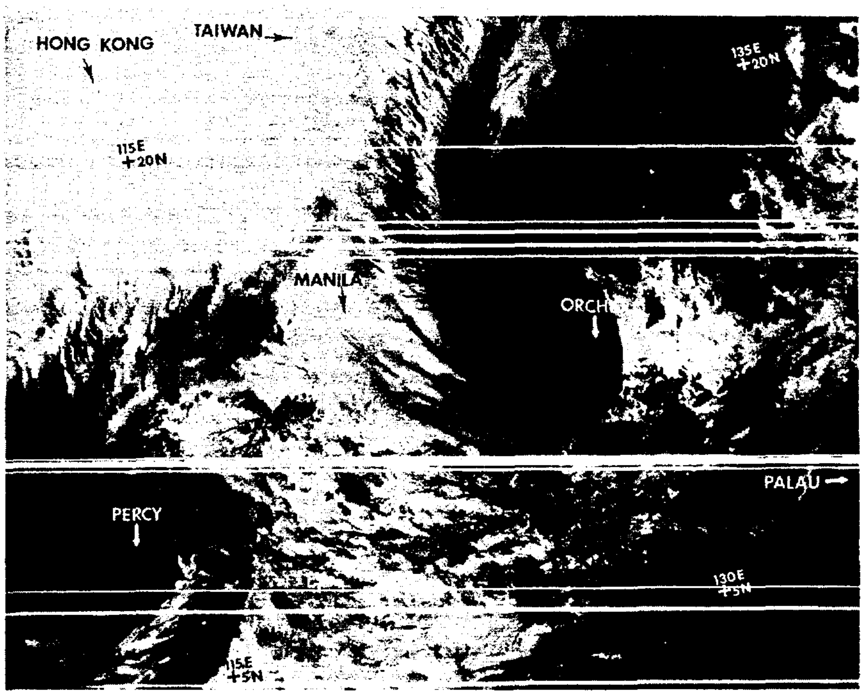
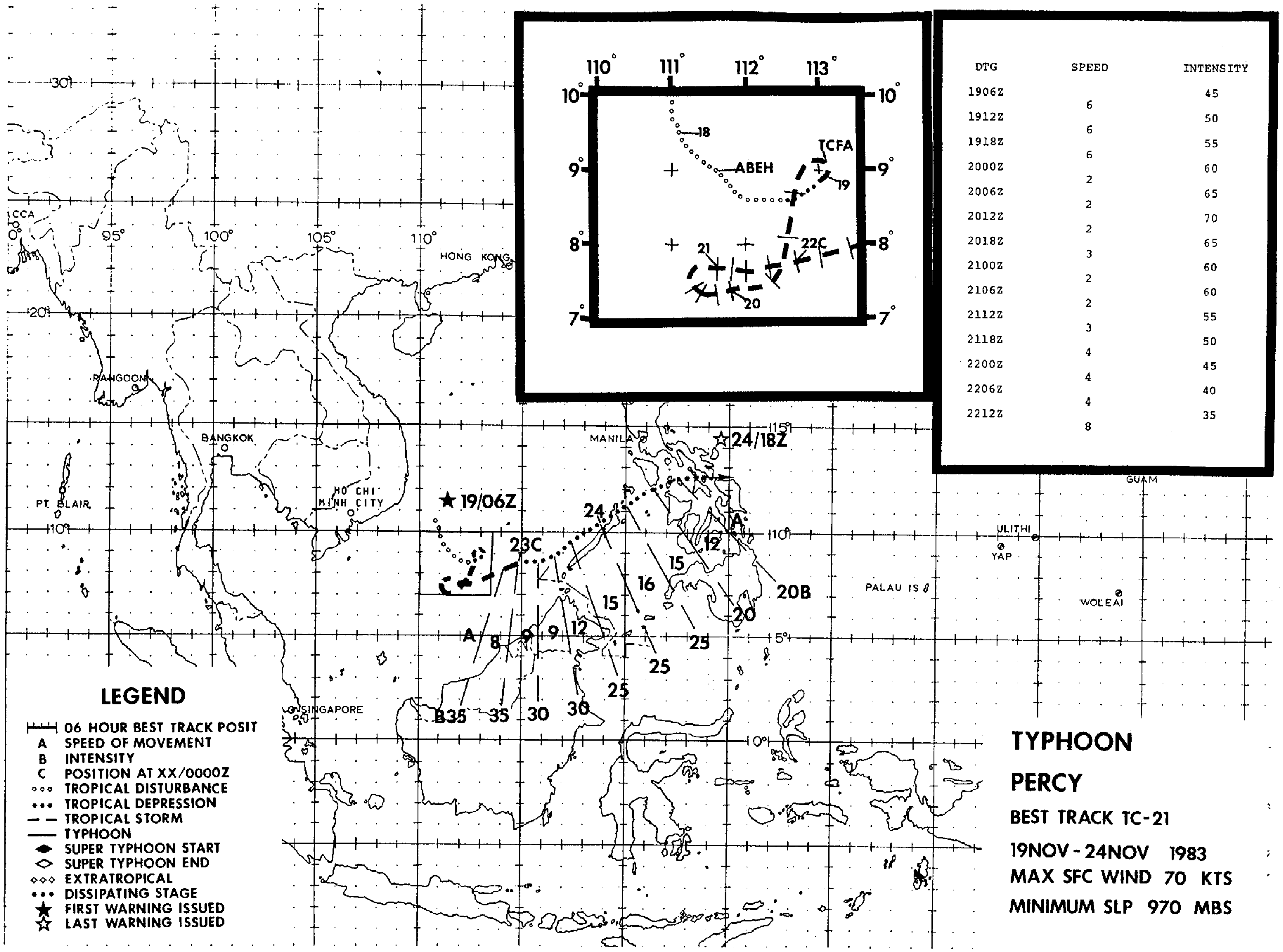


Figure 3-20-1. Orchid as a tropical storm (right) and the disturbance which developed into Typhoon Percy (left) (182336Z November NOAA 8 infrared imagery).

As Orchid weakened, the influence of low-level steering became greater and the circulation moved southward. By the time of the final warning, Orchid was located 40 nm (74 km) west of the position it had occupied five and a half days earlier.

Although Orchid posed a threat to the Philippine Islands for several days, landfall was not made on any of the islands. However, high winds and seas associated with Orchid posed a hazard to maritime interests at great distances from the center. An inter-island ferry, MV Dona Cassandra (487 tons) capsized and sank in the Suriago Strait during a transit between Butuan, Mindanao and Cebu. Of the 387 passengers and crew onboard, 167 were killed.

In addition to the loss of the Dona Cassandra, Orchid was responsible for damages to the SS Mallory Lykes. Mallory Lykes was headed west across the Philippine Sea when she passed close to Orchid's center. The 60 kt (31 m/s) winds and 24 ft (7 m) seas encountered by the ship caused two engines carried as cargo to break free of their lashings. These eight ton engines caused considerable damage to hull frames and plating as they clattered about but fortunately did not injure any personnel.



DTG	SPEED	INTENSITY
1906Z		45
	6	
1912Z		50
	6	
1918Z		55
	6	
2000Z		60
	2	
2006Z		65
	2	
2012Z		70
	2	
2018Z		65
	3	
2100Z		60
	2	
2106Z		60
	2	
2112Z		55
	3	
2118Z		50
	4	
2200Z		45
	4	
2206Z		40
	4	
2212Z		35
	8	

From genesis to dissipation, every aspect of Percy's life was affected in some manner by its proximity to Typhoon Orchid (20W). As Orchid neared the Philippines on 17 November, an area of upper-level divergence was created over the South China Sea where Orchid's outflow split into southerly and easterly components. Beneath this upper-level divergence, the confluence of the northeasterly monsoon and the southwesterly inflow into Orchid created an area of high positive vorticity. Typhoon Percy formed in this fertile environment.

A tropical disturbance quickly formed but showed no signs of further development until 1600Z on the 18th. In the eight hour period between 181600Z and 190000Z, the disturbance intensified rapidly, forming convective bands and an upper-level anticyclone. A TCFA was issued at this time and was followed rapidly by a warning when continued intensification became apparent from satellite imagery (Figure 3-21-1). A reconnaissance aircraft investigated the area shortly after issuance of the first warning and found a well-developed tropical storm with a circular eye and maximum sustained winds of 50 kt (26 m/s).

Percy moved very erratically for the first four days in warning status. After completing a series of loops and feints, Percy's position at 230600Z was only 90 nm (170 km) from its position at 190600Z. The proximity of Orchid to the northeast of Percy and the complicated steering environment in which both systems were embedded made forecasting especially difficult. The possibilities were endless; Fujiwhara interactions or the entrainment of one system into the other were two of the scenarios considered at the time by JTWC forecasters.

Percy eventually sheared and became embedded in Orchid's inflow, but not before achieving typhoon status and a maximum intensity of 70 kt (36 m/s). The reports of reconnaissance aircraft throughout Percy's life best tell the story. On 19 November, the first aircraft encountered a well-developed tropical storm with 50 kt (26 m/s) winds and a circular eye. The next mission at 200905Z encountered a 70 kt (36 m/s) typhoon with an MSLP of 971 mb. By 202344Z, Percy was beginning to shear and the aircraft reported a ragged elliptical eye with a poor radar presentation. The 210950Z reconnaissance flight reported that Percy no longer had an eye and that all clouds were below the 700 mb flight level. By the time of the 230241Z mission, Percy was an exposed low-level circulation with maximum sustained winds of 35 kt (18 m/s). The final aircraft reconnaissance mission, at 240200Z, was unable to fix Percy. The final warning on Percy was issued at 241800Z when it became impossible to identify the circulation.

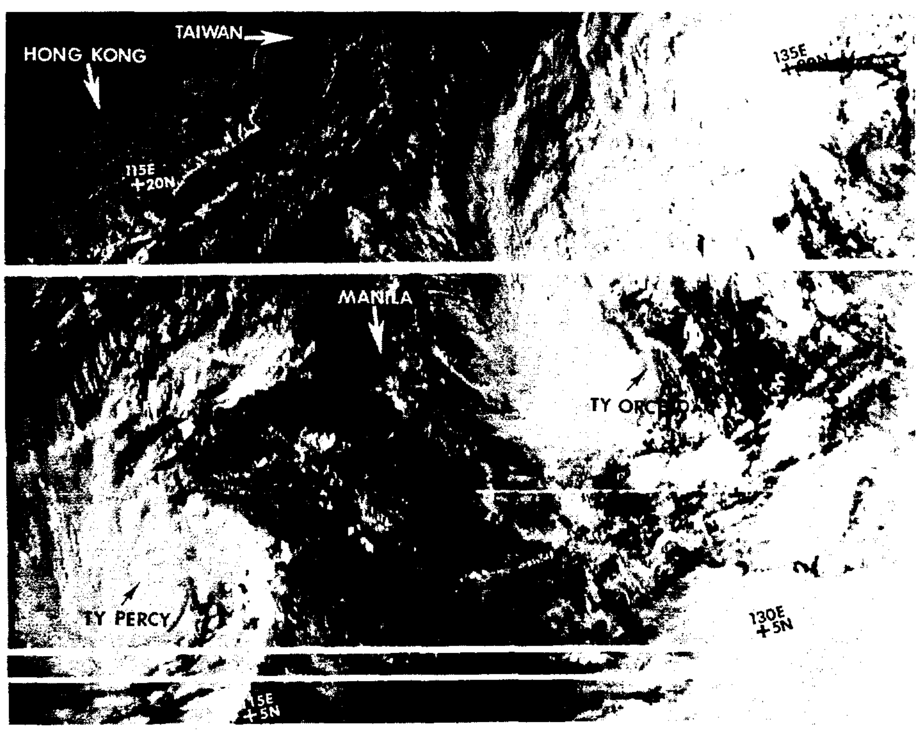


Figure 3-21-1. Percy (left) and Orchid (right), both at tropical storm intensity (182336Z November NOAA 8 visual imagery).

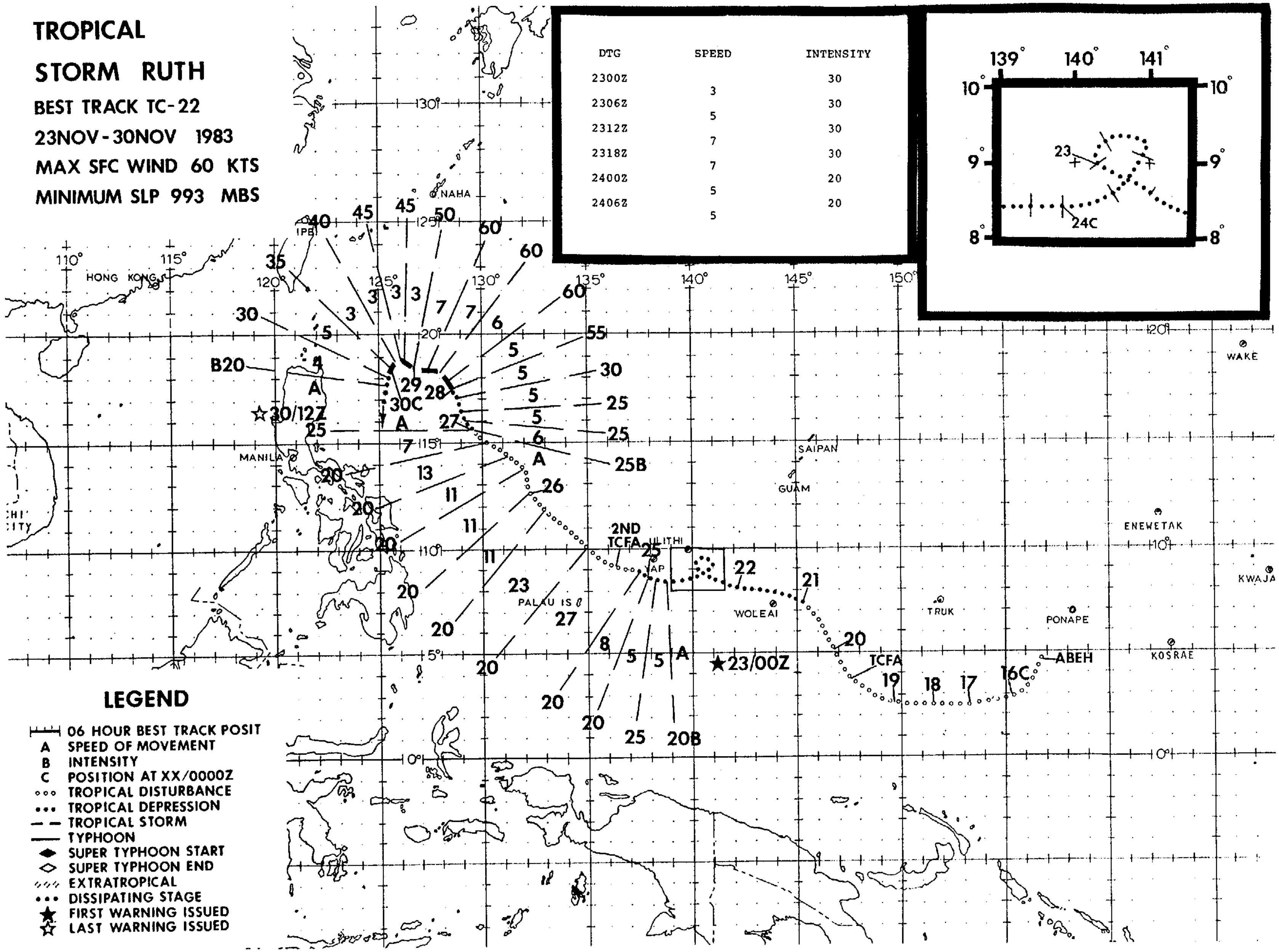
TROPICAL STORM RUTH

BEST TRACK TC-22

23NOV-30NOV 1983

MAX SFC WIND 60 KTS

MINIMUM SLP 993 MBS



DTG	SPEED	INTENSITY
2300Z		30
	3	
2306Z		30
	5	
2312Z		30
	7	
2318Z		30
	7	
2400Z		20
	5	
2406Z		20
	5	

LEGEND

- 06 HOUR BEST TRACK POSIT
- A SPEED OF MOVEMENT
- B INTENSITY
- C POSITION AT XX/0000Z
- ∘∘∘ TROPICAL DISTURBANCE
- ••• TROPICAL DEPRESSION
- — — TROPICAL STORM
- —— TYPHOON
- ◆ SUPER TYPHOON START
- ◇ SUPER TYPHOON END
- EXTRATROPICAL
- ••• DISSIPATING STAGE
- ★ FIRST WARNING ISSUED
- ☆ LAST WARNING ISSUED

Ruth was one of the more erratic storms of 1983. It dissipated, regenerated, looped, moved at speeds varying from 3 to 25 kt (6-46 km/hr), and was the subject of four TCFA's and two final warnings.

Ruth was first detected as a tropical disturbance embedded in the near-equatorial trough southeast of Guam. The disturbance was discussed in the Significant Tropical Weather Advisory (ABEH PGTW) on 15 November and was monitored closely for the next four days as it moved westward along the trough axis. Little change in organization or intensity was observed during this period. MSLP was fairly constant at 1008 mb and surface winds in the area were 5-10 kt (3-5 m/s).

On the 19th of November, the disturbance showed signs of development. Associated convective activity expanded to cover a large area approximately 1200 nm (2222 km) east and west by 900 nm (1667 km) north and south. Convection was intense and weakly banded into a center near 5N 147E. A TCFA was issued for the disturbance at 191600Z when surface winds picked up to 15-25 kt (8-13 m/s).

The disturbance was continued in alert status for four days as it moved slowly northwestward without any further development. Aircraft reconnaissance flights into the area on the 20th and 21st were unable to close off a surface center and provided data indicating the presence of a surface trough or circulation of synoptic scale. Ruth's arrested development at this stage was due to the presence of Orchid to the west and the passage of a frontal system to the northwest. Although inflow on the north side of Ruth was provided in abundance by the Trade Winds, inflow on the south side was very weak. Most of the low latitude westerly flow was drawn into Orchid leaving an area of weak westerlies to the east of Orchid flowing into Ruth. The frontal system to the northwest of Ruth interacted with the subtropical ridge to create an area of enhanced mid-level flow inhibiting the development of a circulation at the mid-levels.

In spite of these factors, Ruth was able to maintain convective organization and even intensified slightly with maximum sustained winds reaching 30 kt (15 m/s). A reconnaissance aircraft on an investigative mission at 222345Z was able to close off a surface circulation with MSLP of 1004 mb. The first warning on Ruth as a tropical depression was issued on receipt of this report and projected continued slow intensification and north-northwestward movement.

Ruth maintained 30 kt (15 m/s) intensity for the next 24 hours as it completed an anticyclonic loop but appeared on satellite imagery to be shearing in the process. Warnings were terminated at 240000Z after data from reconnaissance aircraft indicated that maximum sustained winds associated with the circulation were 20 kt (10 m/s).

Over the next four days, Ruth moved quite erratically while exhibiting wide ranging fluctuations in its convective signature on satellite imagery. A TCFA was issued at 250820Z when reconnaissance aircraft located a broad circulation with maximum surface winds of 25 kt (13 m/s) and MSLP of 1004 mb. Ruth remained in alert status until satellite imagery on the 26th indicated that the circulation was shearing. Ruth was placed in alert status again at 270343Z when it appeared from satellite imagery that the circulation was regaining vertical alignment. Synoptic conditions at this time were favorable for further development. Typhoon Orchid had weakened to a tropical depression and no longer competed with Ruth for inflow. At the same time, the destructive interaction between Ruth and the frontal system previously discussed was broken as the front propagated eastward.

Ruth flourished in this environment and intensified rapidly. A reconnaissance aircraft reported surface winds of 55 kt

(28 m/s) and MSLP of 997 mb at 272340Z just prior to the resumption of warnings on Ruth at 280000Z. Maximum winds associated with Ruth were higher than would be expected from the MSLP due to the enhancement of Ruth's circulation by an intense northeasterly monsoon gale area on its northwest side.

Ruth peaked at a maximum intensity of 60 kt (31 m/s) briefly on the 28th before the shearing effects of its environment caused it to weaken for the final time. Ruth was able to intensify to near typhoon intensity in spite of its location in an area of moderate vertical shear. However, when the northeasterly monsoon flow was enhanced further by a cold outbreak from the continent, the resultant increase in vertical shear proved to be too much for the plucky little system. Ruth weakened rapidly after shearing and dissipated as an exposed low-level circulation on the 30th.

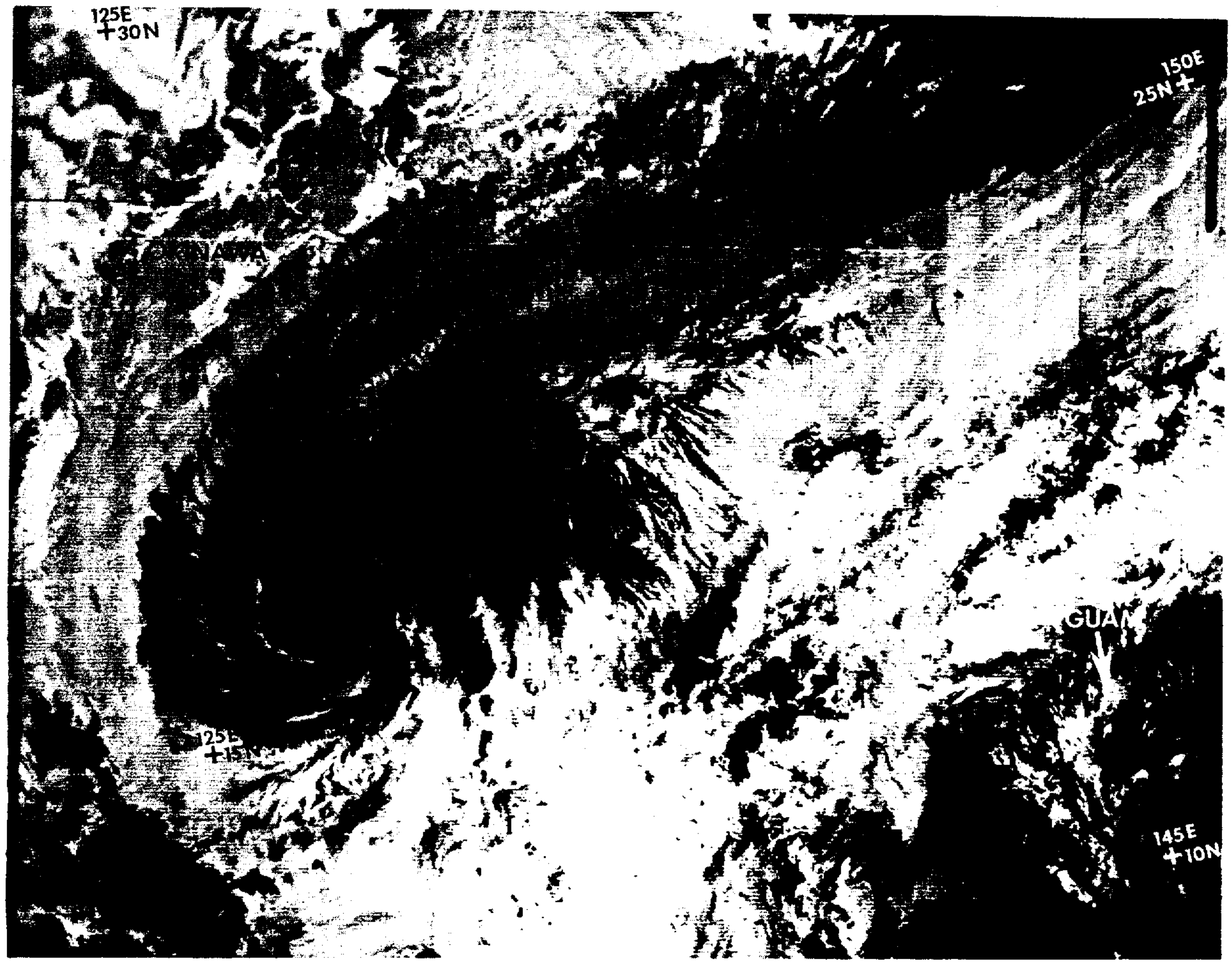
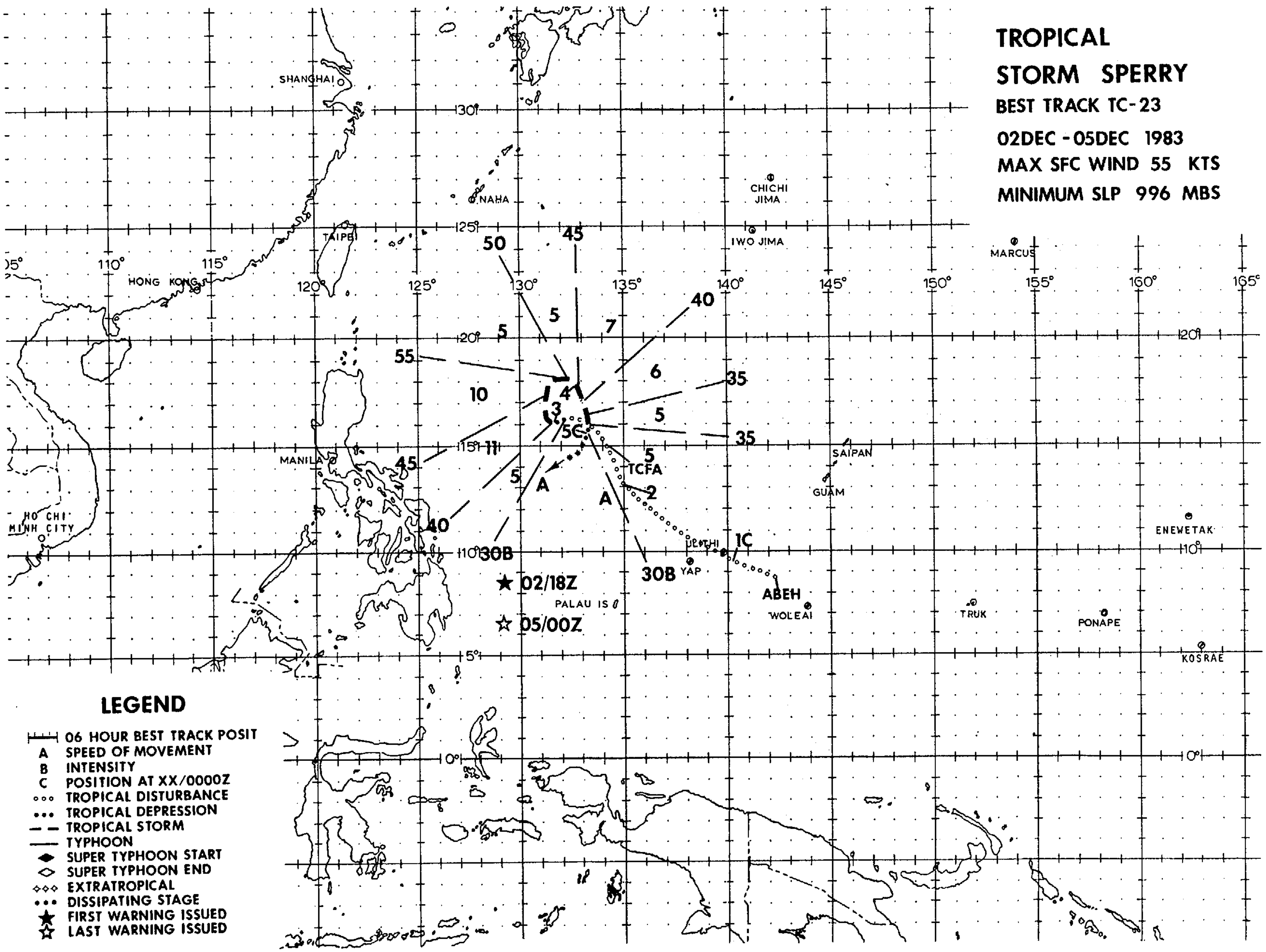


Figure 3-22-1. Tropical Storm Ruth near maximum intensity. Interaction with the frontal boundary to the north and the cold air outbreak south of Japan led to Ruth's destruction two days later (280935Z November DMSP infrared imagery).


TROPICAL STORM SPERRY
BEST TRACK TC-23
02DEC - 05DEC 1983
MAX SFC WIND 55 KTS
MINIMUM SLP 996 MBS
LEGEND
06 HOUR BEST TRACK POSIT
A SPEED OF MOVEMENT
B INTENSITY
C POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
DISSIPATING STAGE
FIRST WARNING ISSUED
LAST WARNING ISSUED
★ 02/18Z
☆ 05/00Z
TCFA
SHANGHAI
NAHA
CHICHI JIMA
IWO JIMA
MARCUS
TAIPEI
HONG KONG
MANILA
HO CHI MINH CITY
SAIPAN
GUAM
ULITHI
YAP
WOLEAI
PALAU IS
TRUK
PONAPE
ENEWETAK
KOSRAE

The disturbance which became the 23rd tropical cyclone of the year originated in an elongated band of unorganized convection associated with a near-equatorial trough. This cyclone, eventually called Sperry, was to be a short-lived system, lasting about two and one-half days before dissipating in a manner similar to that of two of its predecessors - Typhoon Orchid and Tropical Storm Ruth.

As the remnants of Tropical Storm Ruth faded away, the monsoon trough became active again and reestablished itself, stretching from the south Philippine Sea eastward to the Marshall Islands. The convective activity covered a broad area between 4-10N and 130-150 E. On the 30th of November, a surface circulation embedded in the trough about 400 nm (740 km) south of Guam appeared to be gaining in organization and intensity. MSLP at this time was 1009 mb and associated winds were 10 to 15 kt (5-8 m/s). Over the following 24 hours, MSLP in the circulation dropped to 1006 mb and convective activity increased significantly.

At this point, it appeared that the circulation was well organized and on its way to becoming a significant tropical cyclone with a few more days of development. However, between 010000Z and 011200Z December, the center of convective activity shifted to a point 500 nm (926 km) to the northwest. This radical shift was accompanied by the development of an upper-level anticyclone over the new location. Continued intensification of the center led to the issuance of a TCFA at 0300Z on the 2nd. Shortly after the issuance of this alert, a reconnaissance aircraft investigated the area and found an elongated surface trough with pressures around 1006 mb and winds of 15-30 kt (8-15 m/s).

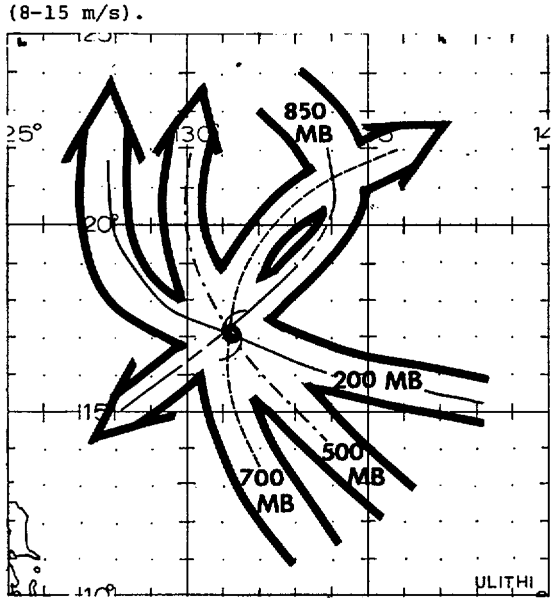


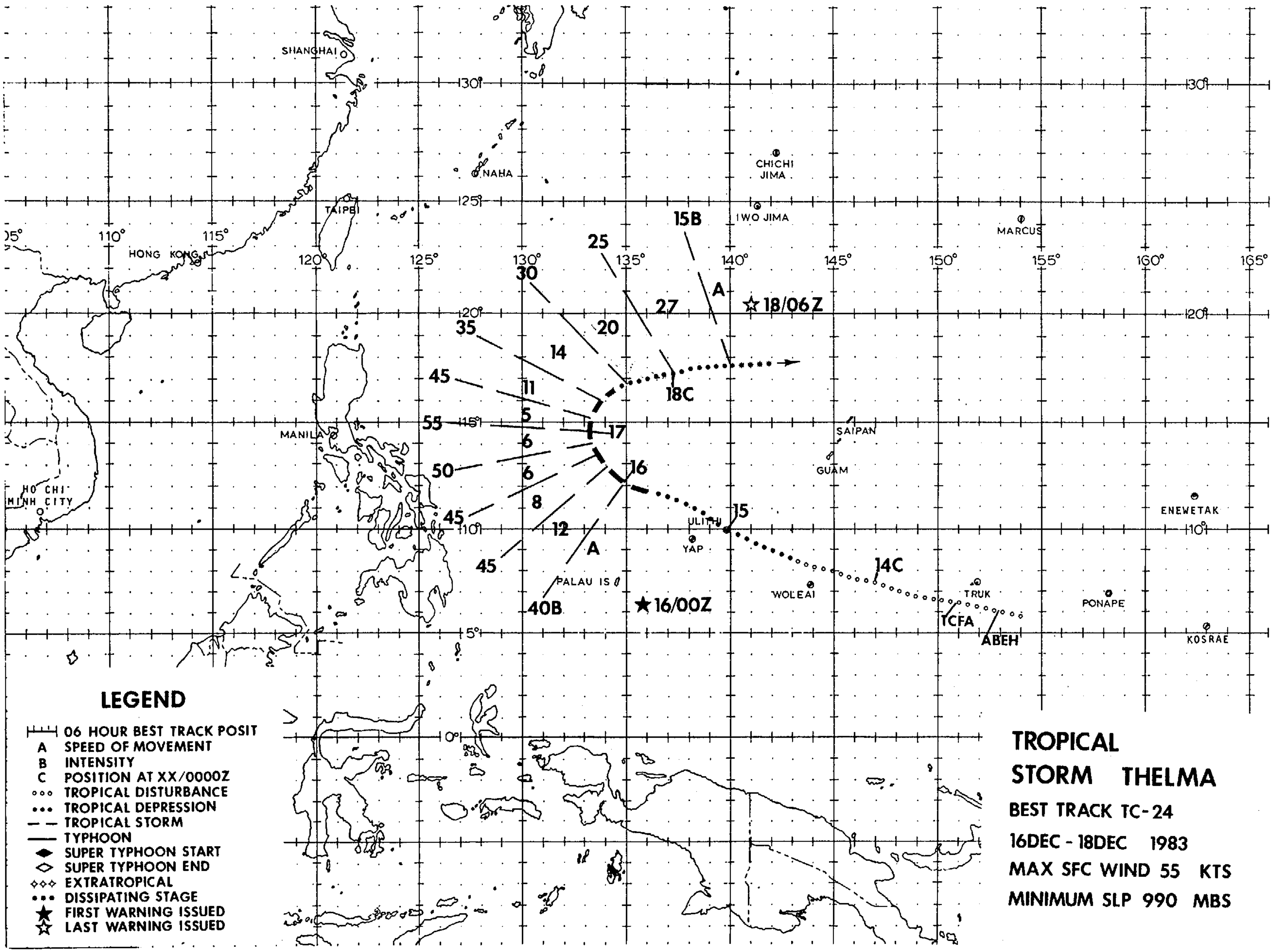
Figure 3-23-1. Diagram illustrating the direction of steering flow at various levels in the vicinity of Sperry.

The first warning on Sperry was issued at 021800Z when analysis of satellite imagery resulted in a Dvorak T-number of 2.5 or 35 kt (18 m/s). The accuracy of this analysis was confirmed a few hours later by reconnaissance aircraft. Data collected by reconnaissance aircraft indicated that Sperry exhibited considerable tilt. The surface center was displaced 30-60 nm (56-111 km) to the south of the 700 mb center. This was not unexpected since the circulation was located in an area of strong vertical shear. Figure 3-23-1 illustrates the steering influences acting on Sperry at the time. Tilting of the system prior to shearing away of the upper portion of the circulation is a common occurrence in this situation. Therefore, it came as a surprise when Sperry regained vertical alignment and intensified. Maximum intensity of 55 kt (28 m/s) was achieved as Sperry turned eastward at 031200Z. Figure 3-23-2 shows Sperry near maximum intensity.

The forecast at this point called for Sperry to complete an anticyclonic loop and dissipate over water as an exposed low-level circulation. This forecast was a radical departure from persistence. Over the previous 18 hours, Sperry had intensified from a tropical depression to an intense tropical storm. At the same time, Sperry's speed of motion doubled as it turned northward, then northeastward. Persistence in this case called for continued northeastward movement and intensification.

Sperry sheared as expected and moved southward while weakening over the next 36 hours. The final warning was issued at 050000Z when data from reconnaissance aircraft indicated that Sperry's MSLP had risen to 1010 mb and maximum sustained winds had dropped to 20 kt (10 m/s).

Figure 3-23-2. Tropical Storm Sperry at maximum intensity while undergoing an anticyclonic loop (031335Z December DMSP infrared imagery).



TROPICAL STORM THELMA
BEST TRACK TC-24
16DEC - 18DEC 1983
MAX SFC WIND 55 KTS
MINIMUM SLP 990 MBS

Thelma, the final tropical cyclone of the 1983 season, formed to the east of the Caroline Islands during mid-December. It was the only late-season cyclone to recurve in the western Philippine Sea.

Thelma was initially detected on 11 December as a weak surface circulation embedded in the near-equatorial trough near 4N 170E. Upper-level flow in the area was highly divergent due to the presence of a TUTT cell to the north of the low-level trough. A broad area of convective activity existed below the divergent upper-level flow, and was not confined to the proximity of the low-level circulation.

Over the next two days, the TUTT cell moved westward into a position to the northwest of the low-level circulation. An anticyclone formed over the low-level circulation in the lee of the TUTT, prompting the issuance of a TCFA at 131200Z.

Thelma remained in alert status for two and one-half days while moving rapidly westward. Repeated investigative flights by reconnaissance aircraft during this period provided data indicating that the circulation remained poorly defined. Concurrently, Thelma's appearance on satellite imagery indicated that the system was becoming better organized with well-developed outflow.

The first warning on Thelma, as a tropical storm, was issued when reconnaissance aircraft located a tight circulation center at 160100Z. MSLP was 996 mb and maximum surface winds observed were 40 kt (21 m/s). The forecast called for Thelma to continue moving west-northwestward for the first 24 hours, then shear and assume a westward track as an exposed low-level circulation. Three previous storms (Orchid, Ruth, and Sperry) had reacted in a like manner under similar circumstances. These storms had reacted to the passage of a mid-latitude frontal system by shearing under the pressure of enhanced but opposing flows at lower and middle-levels. As the frontal system approached to the northwest of Thelma, a repeat of these performances was expected.

Thelma's classic recurvature in advance of the front proved the fallacity of JTWC's forecast reasoning. Thelma's environment differed from its predecessors' in that it was not embedded in strong northeasterly flow at the low-levels. Although the northeasterly monsoon was well established in close proximity to the Asian Continent, Thelma was beyond its influence in the central Philippine Sea.

Thelma achieved maximum intensity of 55 kt (28 m/s) just prior to recurving on the 17th. After recurvature, Thelma dissipated rapidly under the effects of intense vertical shear (Figure 3-24-1). The strength of the upper-level flow impacting Thelma is reflected in the rapidity with which the system sheared while moving northeastward at speeds up to 27 kt (50 km/hr).

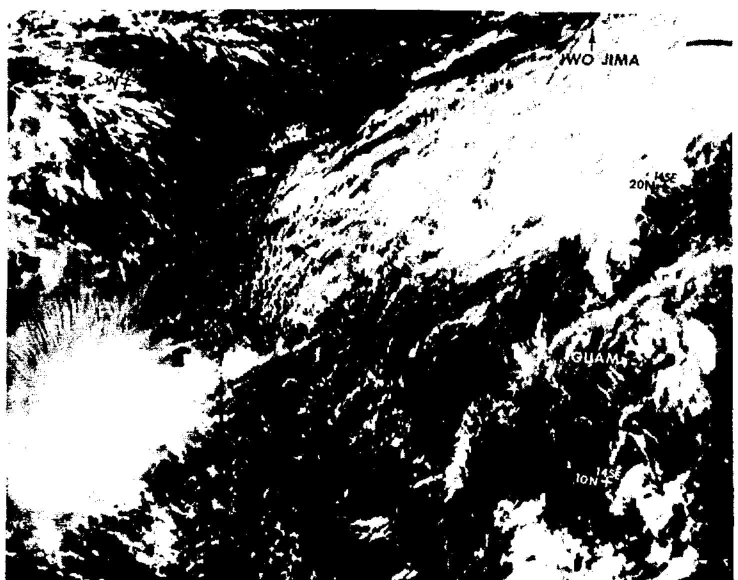


Figure 3-24-1. After recurvature, Thelma quickly dissipated and became absorbed into the frontal system. Only 24 hours after maximum intensity, the remains of Thelma were no longer distinguishable from the frontal system (upper right). The cloud feature at lower left is not associated with Thelma but is a "blow-up" frequently observed at the trailing edge of a front in the western North Pacific (180056Z December DMSP visual imagery).

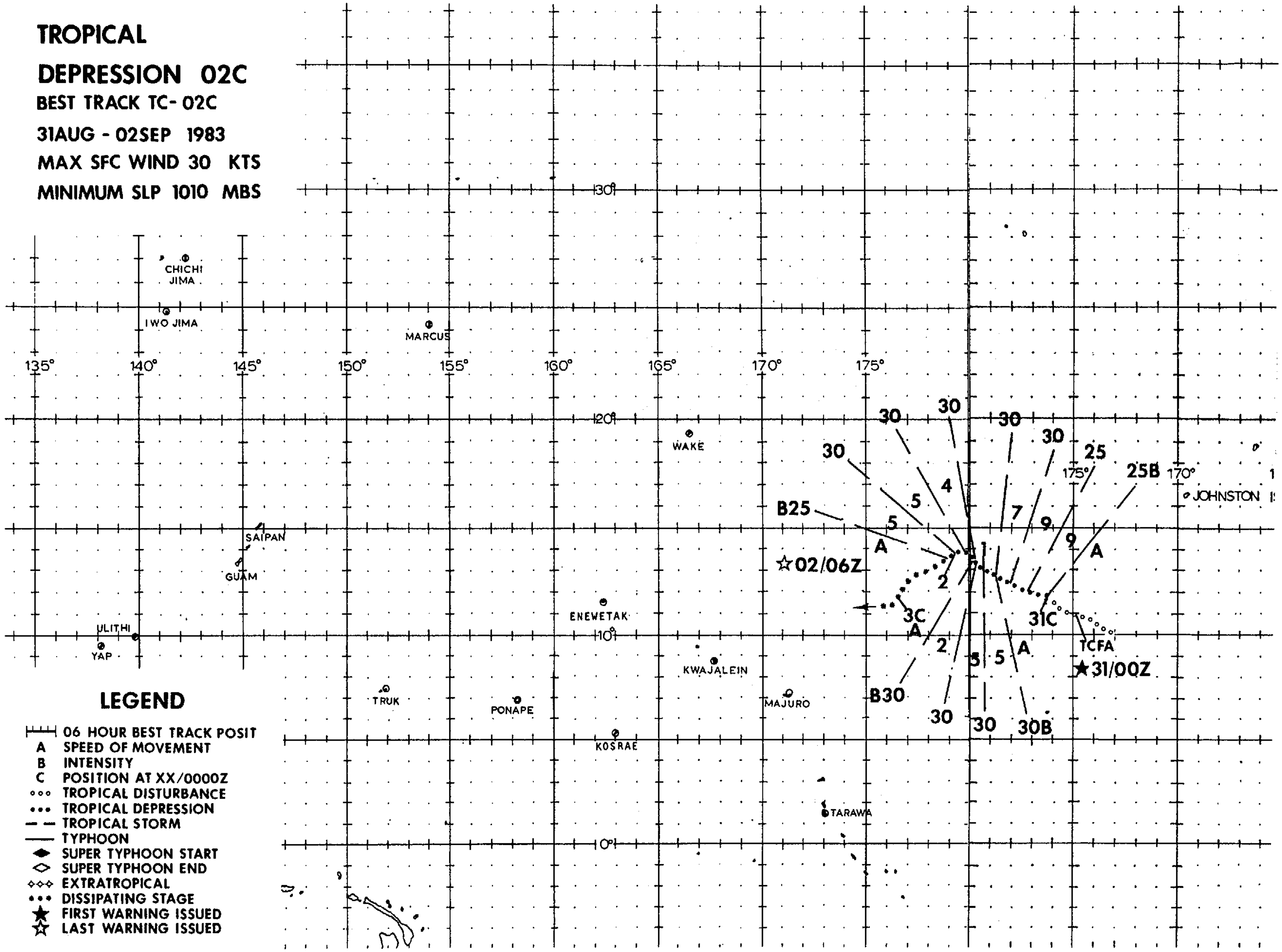
TROPICAL DEPRESSION 02C

BEST TRACK TC-02C

31AUG - 02SEP 1983

MAX SFC WIND 30 KTS

MINIMUM SLP 1010 MBS



During late August, two tropical disturbances developed in the central North Pacific Ocean, east of the International Dateline, and tracked westward into the JTWC area of responsibility. The first of these disturbances crossed the dateline on 27 August and later became Typhoon Ellen (10W). As this disturbance moved westward toward Enewetak Atoll (WMO 91250), a second disturbance began to develop southwest of Johnston Island (WMO 91275). At 301530Z, the Naval Western Oceanography Center, Pearl Harbor, Hawaii, issued a TCFA for this disturbance, which was followed by the initial warning at 310600Z from the Central Pacific Hurricane Center (CPHC), Honolulu, Hawaii.

During the first 24 hours in warning status, Tropical Depression 02C moved toward the northwest and the dateline. At 312345Z August, satellite fix information from the National Environmental Satellite, Data and Information Service (NESDIS) office in Honolulu, Hawaii, indicated that Tropical Depression 02C had reached the dateline (see Figure 3-25-1). Based on this information, the CPHC issued their final warning for 010000Z September position and transferred warning responsibility to the JTWC.

After 010000Z, satellite fix positions began to oscillate east and west of the dateline. It seems likely that Tropical Depression 02C may have slowed, or moved erratically, near the dateline before resuming a westward track on 2 September. During this period, a break in the subtropical ridge was present northwest of Tropical Depression 02C. Tropical Depression 02C was forecast to respond to this break by moving slowly northwestward. However, that response was never realized, and once the subtropical ridge strengthened, Tropical Depression 02C moved west-southwestward and eventually dissipated over open water.

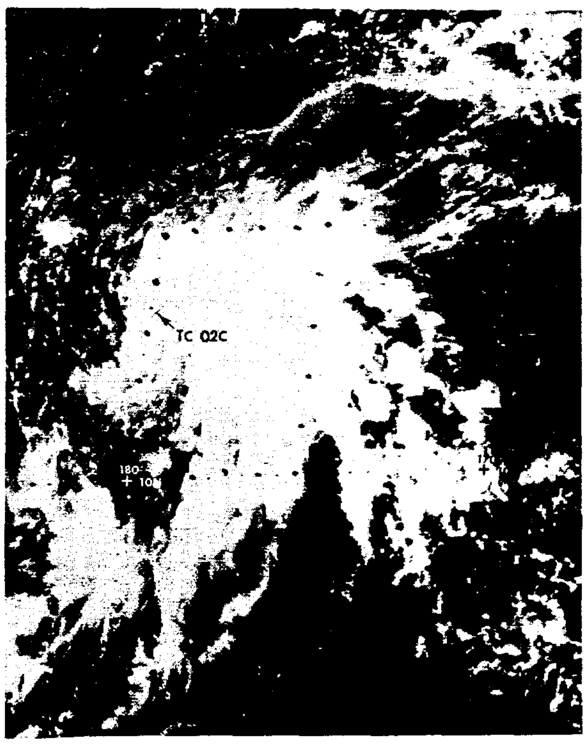


Figure 3-25-1. Tropical Depression 02C at its peak intensity. This imagery provided information to both the CPHC and JTWC that Tropical Depression 02C had reached the dateline. However, it was 24 hours later that satellite fix data indicated a significant movement westward from the dateline (312345Z August GOES-West visual imagery, courtesy of the National Environmental Satellite, Data and Information Service, Honolulu, Hawaii).

2. NORTH INDIAN OCEAN TROPICAL CYCLONES

Tropical cyclone activity in the North Indian Ocean was below normal during 1983. Only three storms originated in this area as compared to the annual average of 4.6. A fourth system, Tropical Storm Kim, moved into the area from the western North Pacific. (See Tropical Storm Kim (16W)). Tables 3-6 and 3-7 provide a summary of North Indian Ocean tropical cyclone activity.

TABLE 3-6. NORTH INDIAN OCEAN

1983 SIGNIFICANT TROPICAL CYCLONES

TROPICAL CYCLONE	PERIOD OF WARNING	CALENDAR DAYS OF WARNING	NUMBER OF WARNINGS ISSUED	MAXIMUM SURFACE WIND (KT)	ESTIMATED MSLP (MB)	BEST TRACK DISTANCE TRAVELED (NM)
1. TC 01A	10 AUGUST	1	3	45	985	461
2. TC 02B	3 OCT - 4 OCT	2	5	50	990	370
3. TC 03B	7 NOV - 9 NOV	3	10	55	980	900
	1983 TOTALS:	6	18			

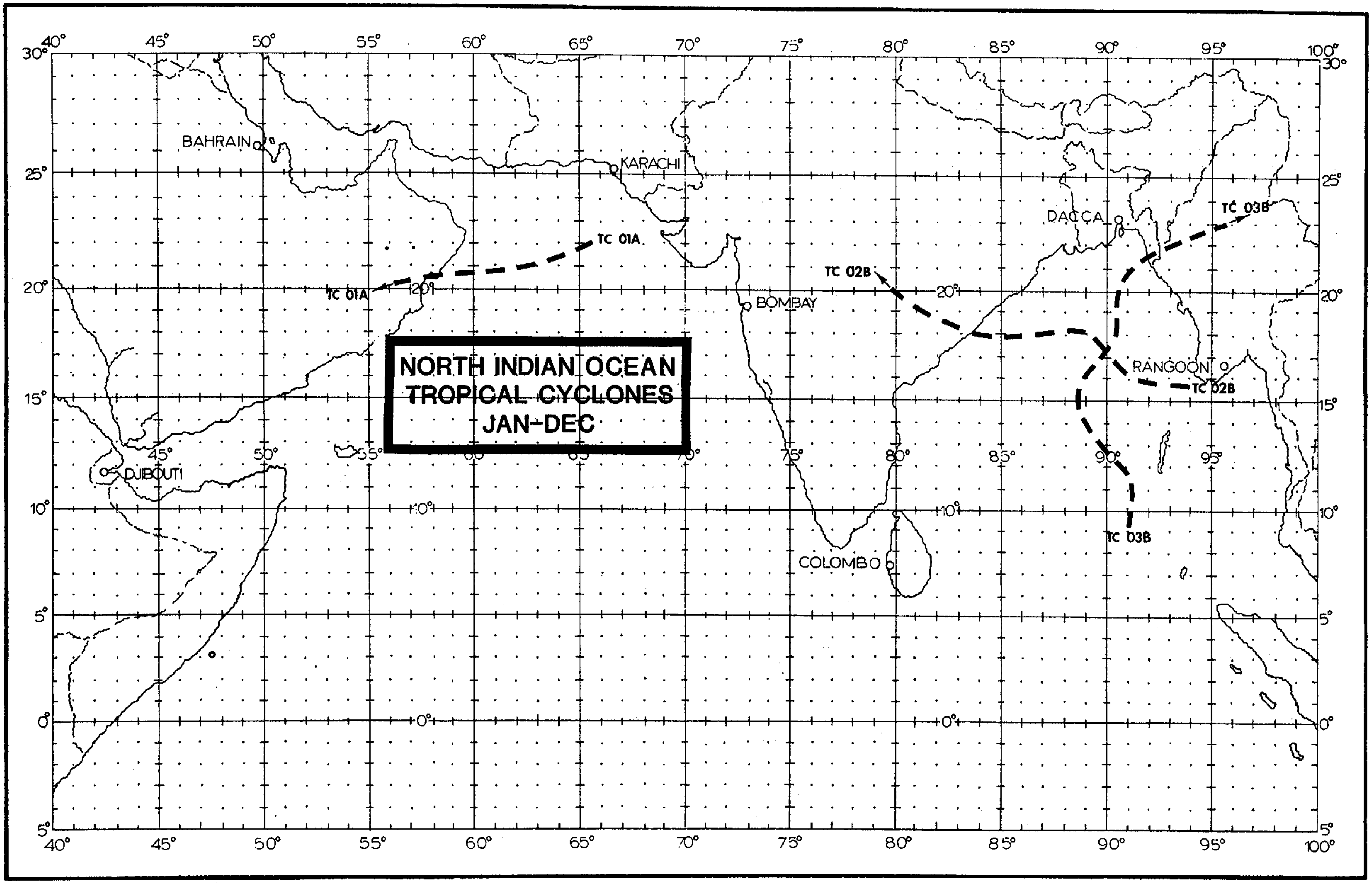
TABLE 3-7.

1983 SIGNIFICANT TROPICAL CYCLONES

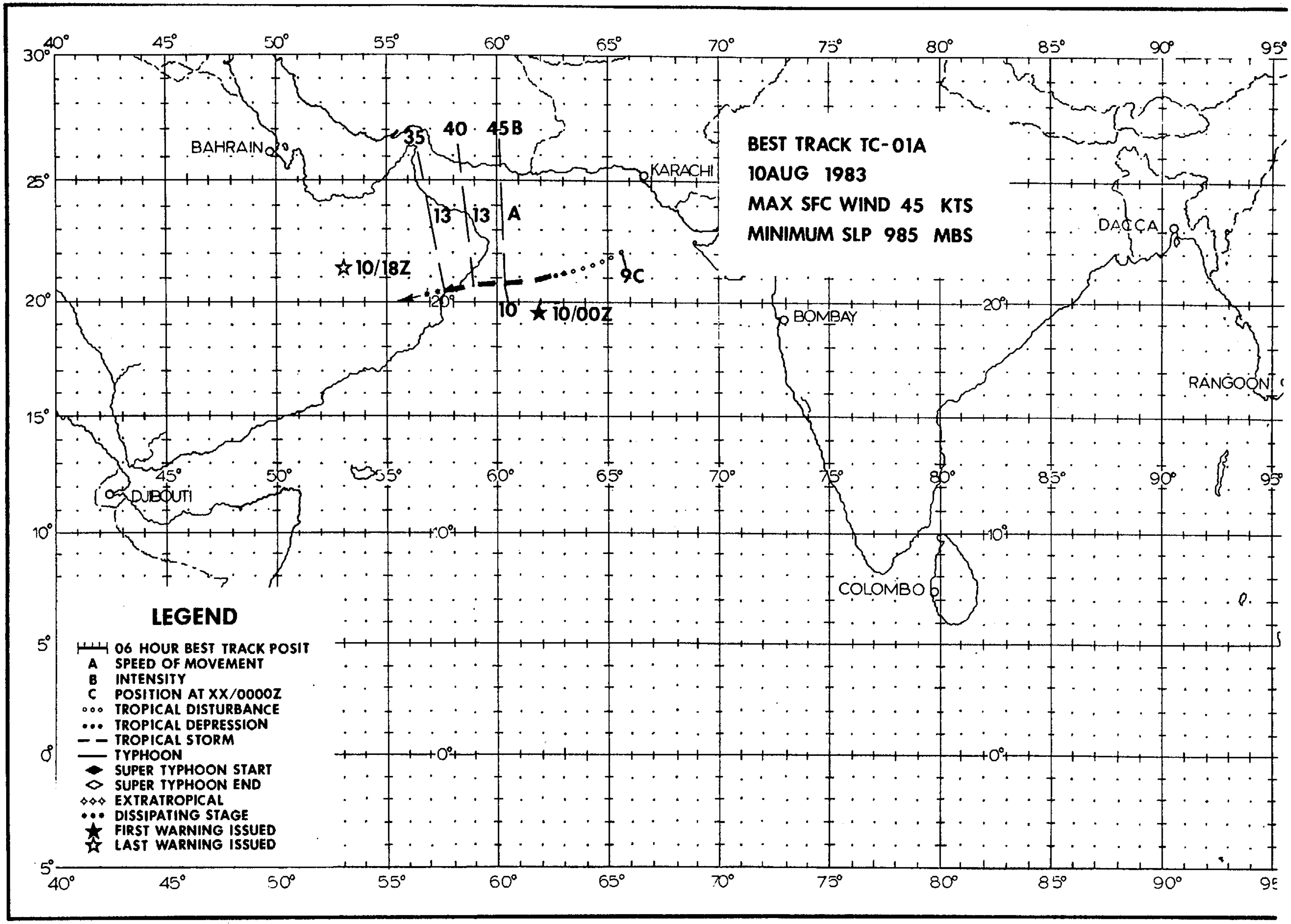
NORTH INDIAN OCEAN	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
ALL TROPICAL CYCLONES	-	-	-	-	-	-	-	1	-	1	1	-	3
1975-1982													
AVERAGE	.1	-	-	.1	.8	.5	-	-	.4	1.0	1.4	.4	4.6
CASES	1	-	-	1	6	4	-	-	3	8	11	3	37

FORMATION ALERTS: Two out of three systems on which Formation Alerts were issued developed into significant tropical cyclones.

WARNINGS:	Number of warning days:	6
	Number of warnings days with two tropical cyclones in region:	0
	Number of warning days with three or more tropical cyclones in region:	0



FWC/JTWC GUAM 3142/62 (NEW 2-76)



FWC/JTWC GUAM 3142/62 (NEW 2-76)

Aurora was first detected on 8 August using satellite imagery. It appeared as a loosely organized area of convective activity in the northern Arabian Sea. Synoptic data was sparse in the area and was not useful for intensity estimation. Dvorak intensity estimates indicated that maximum sustained surface winds in the area were approximately 25 kt (13 m/s). This convective area was monitored by satellite for the next 24 hours and continued to appear loosely organized as it moved westward across the Arabian Sea.

On the 9th of August, the system became better organized and appeared to have formed a coherent surface circulation (Figure 3-26-1). Dvorak intensity estimates continued to reflect tropical depression strength and synoptic data at the time gave no indication of the presence of a surface circulation in the area.

The initial warning was issued at 100000Z after shipboard surface observations indicated the presence of 40 kt (21 m/s) northeasterly winds near Aurora. At the time, Aurora was approximately 90 nm (167 km) east of the coast of Oman with evidence of a strong 35 to 45 kt (18 to 23 m/s) southwesterly monsoon gale area extending to near its latitude. Aurora moved rapidly onshore during the subsequent 12-hour period and dissipated. The final warning was issued at 101800Z, just 18 hours after attaining warning status and less than 42 hours after its initial detection.

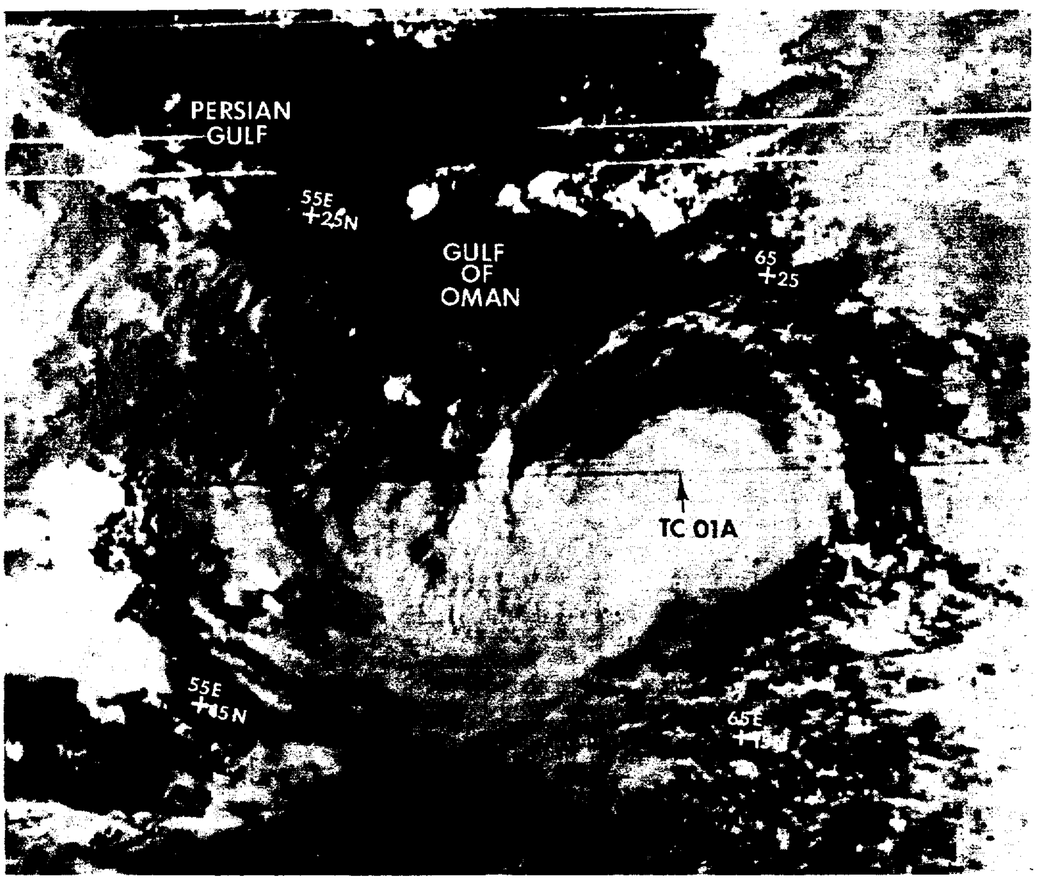
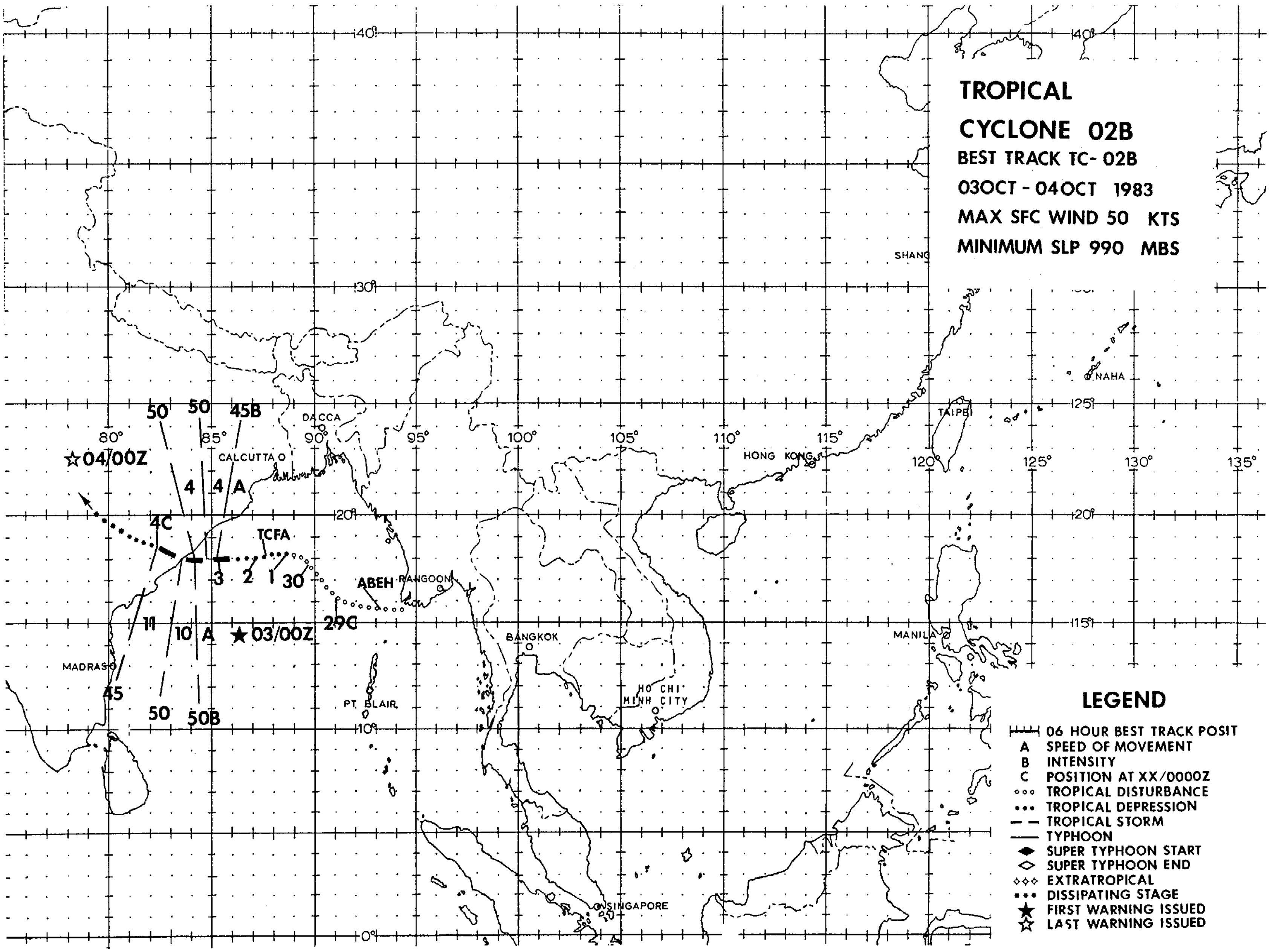


Figure 3-26-1. ***Tropical Cyclone 01A*** *(Aurora) (091057Z NOAA 7 visual imagery).*


TROPICAL
CYCLONE 02B
BEST TRACK TC- 02B
03OCT - 04OCT 1983
MAX SFC WIND 50 KTS
MINIMUM SLP 990 MBS
☆04/00Z
★03/00Z
50
50
45B
4
4
A
4C
TCFA
3
2
1
30
ABEH
29C
11
10
A
45
50
50B
DACCA
CALCUTTA
RANGOON
BANGKOK
MADRAS
PT. BLAIR
HO CHI MINH CITY
SINGAPORE
HONG KONG
TAIPEI
NAHA
MANILA
SHANG
LEGEND
06 HOUR BEST TRACK POSIT
A SPEED OF MOVEMENT
B INTENSITY
C POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
DISSIPATING STAGE
FIRST WARNING ISSUED
LAST WARNING ISSUED

Tropical Cyclone 02B was first detected on 28 September as an area of weakly organized convection located near the southern tip of Burma. Strong upper-level easterly flow over the system inhibitted the formation of outflow channels to the northeast; therefore it moved slowly west-northwestward over the next four days without increasing in organization or intensity. The system eventually moved away from its unfavorable environment and became a significant tropical cyclone.

As Tropical Cyclone 02B continued moving west-northwestward across the Bay of Bengal, its upper-level environment became more favorable for development of the system. Outflow channels became established when the upper-level easterly flow abated over the circulation. A TCFA was issued at 1029Z on the 1st of October in view of the increased potential for further development. This alert was reissued on the 2nd after 24 hours with no further development. The first warning was finally issued at 030000Z. The initial warning on Tropical Cyclone 02B was prompted by satellite imagery which indicated that the system had intensified significantly over the past 24 hours with estimated winds of 45 kt (23 m/s).

The forecast called for continued west-northwestward movement and slight intensification prior to landfall on the eastern coast of India. Tropical Cyclone 02B behaved as expected, making landfall 20 nm (37 km) northeast of Vishakhapatnam, India at 1700Z on the 3rd of October. After making landfall, Tropical Cyclone 02B moved inland over India and dissipated.

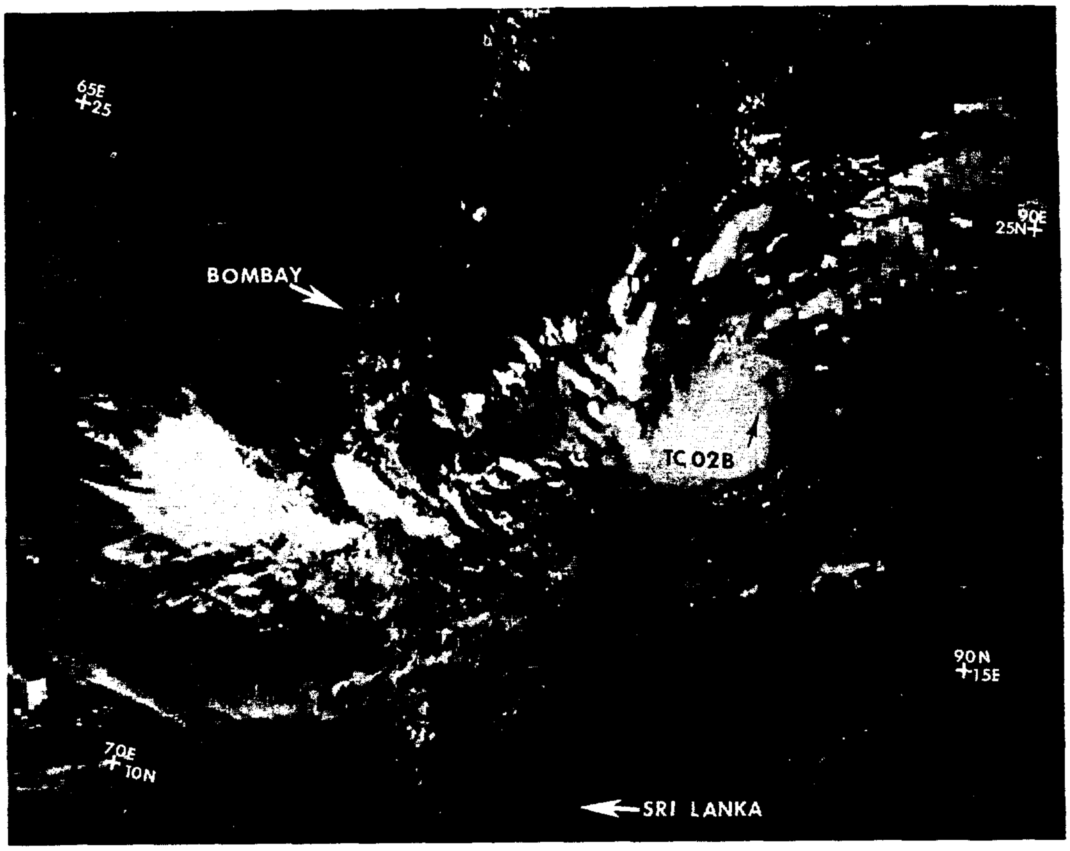
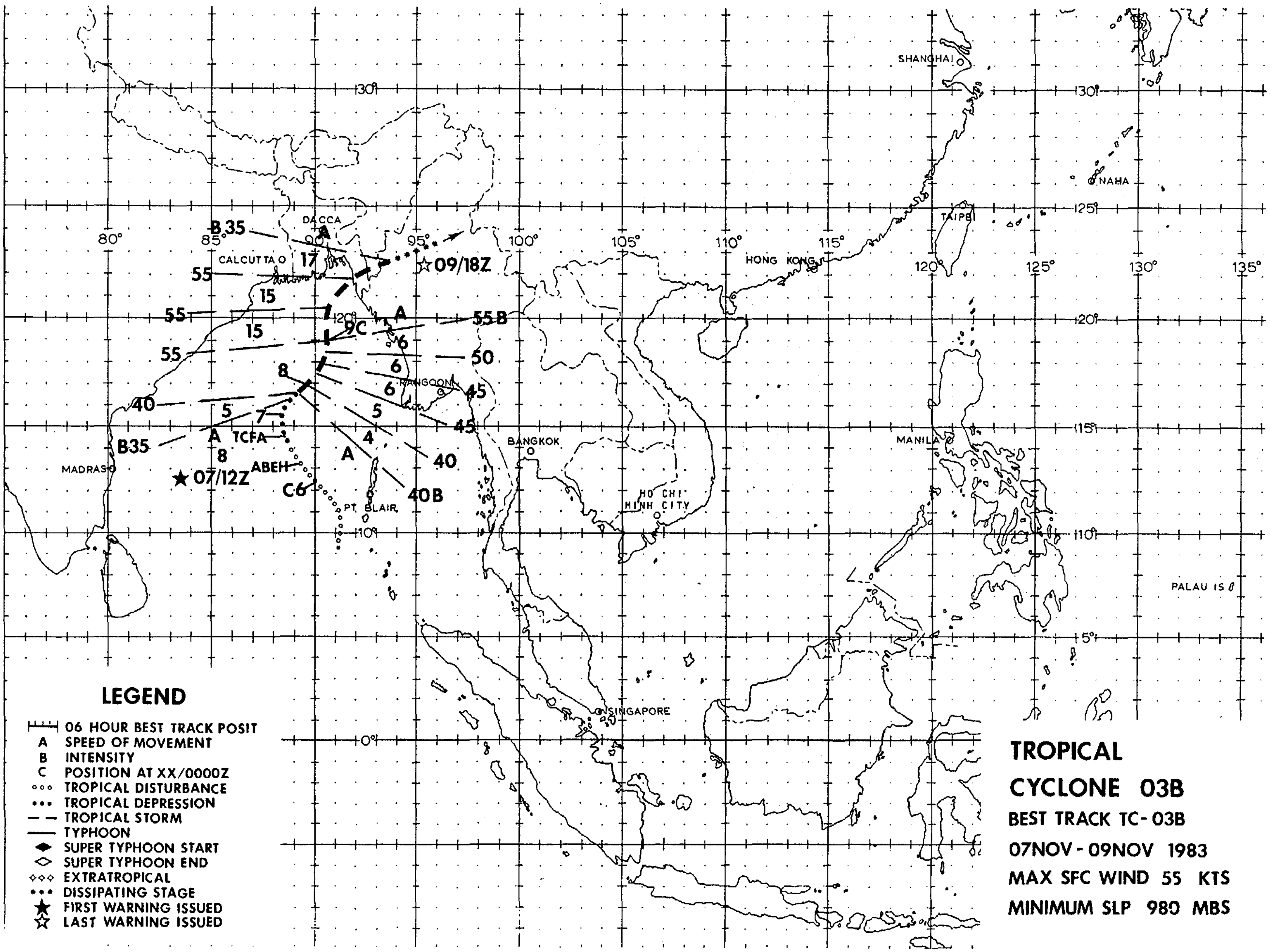


Figure 3-27-1. Tropical Cyclone 02B near maximum intensity seven hours prior to landfall (030948Z October NOAA 7 visual imagery).


TROPICAL CYCLONE 03B
BEST TRACK TC-03B
07NOV-09NOV 1983
MAX SFC WIND 55 KTS
MINIMUM SLP 980 MBS
LEGEND
06 HOUR BEST TRACK POSIT
A SPEED OF MOVEMENT
B INTENSITY
C POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
DISSIPATING STAGE
FIRST WARNING ISSUED
LAST WARNING ISSUED
SHANGHAI
NAHA
TAIPEI
DACCA
CALCUTTA
HONG KONG
RANGOON
BANGKOK
MANILA
MADRAS
PT. BLAIR
HO CHI MINH CITY
PALAU IS
SINGAPORE
07/12Z
09/18Z
TCFA
ABEH
C6
9C
40B
B35
55B
B35

TROPICAL CYCLONE 03B

Tropical Cyclone 03B emerged from the monsoon trough during early November and had a relatively brief and uneventful life. A poorly organized surface circulation in the southern Bay of Bengal had persisted for several days in the monsoon trough. A weak upper-level anticyclone centered over the northern postion of the Bay, placed the low-level circulation in an environment of nondivergent upper-level flow which inhibited further development.

The surface circulation remained poorly organized while moving slowly northward until the 5th of November. At this time, it came into superposition with the upper-level anticyclone which had shifted southward. Over the next 24 hours, satellite imagery indicated the development of convective banding features which prompted the issuance of a TCFA at 1600Z on the 6th.

The circulation continued to intensify while moving north-northwestward. The first warning on Tropical Cyclone 03B was issued at 1444Z on the 7th when satellite intensity estimates reached 35 kt (18 m/s). The lack of synoptic data in the area prompted JTWC to rely on intensity estimates from satellite imagery throughout the life of the cyclone.

After passing the axis of the subtropical ridge, Tropical Cyclone 03B assumed a north-northeastward track and continued to intensify. Maximum intensity of 55 kt (28 m/s) was reached at 0000Z on the 9th. This intensity was maintained until landfall, 12 hours later, on the coast of Bangladesh between Chittagong (WMO 41941) and Cox's Bazar (WMO 41950). Tropical Cyclone 03B continued moving northeastward after landfall and dissipated over northern Burma.

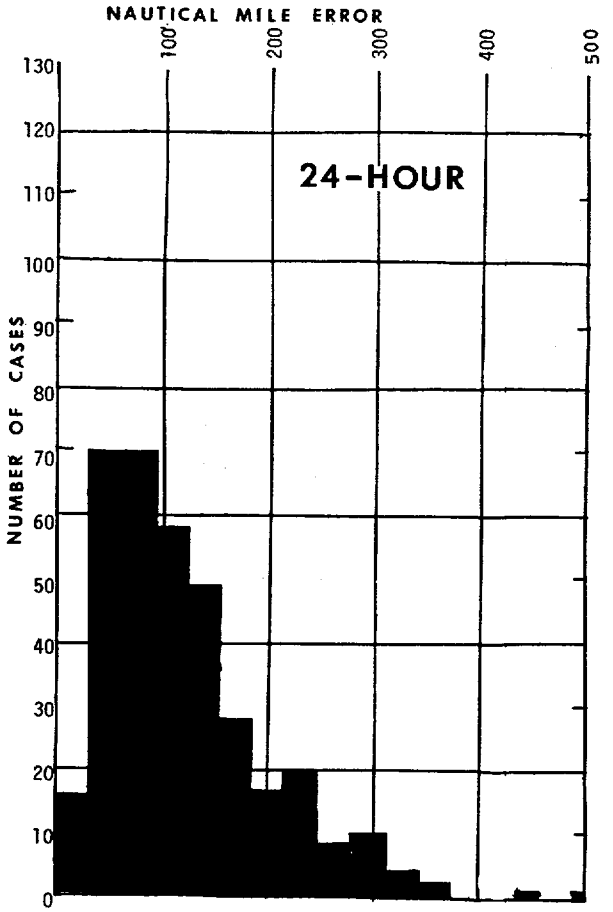


FIGURE 4-2.

Frequency distribution of the 24-, 48-, and 72-hour forecast errors for all significant tropical cyclones in the western North Pacific during the 1983 season.

FORECAST ERRORS (nm)

	24-HR	48-HR	72-HR
MEAN:	117	259	405
MEDIAN:	99	220	331
STANDARD DEVIATION:	76	166	249
CASES:	349	258	187